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NOTES ON INDIAN PLANT TERATOLOGY

BY

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I

On a case of simulated abaxial reproductive proliferation of the hypanthium in a flower of **Calycopteris floribunda** Lamk.

About the middle of March 1921 I came across a few specimens of the shrub *Calycopteris floribunda* Lamk. close to the dam of the Vehar Lake in Salsette, the plants attracting my attention because of the occasional presence of petals in the flowers, a phenomenon which, as far as I am aware, has not been recorded before. The petals were white, narrowly linear, one to five in number, shorter than the calyx-lobes in flower, and inserted close to the sinus. They were not observed associated with the enlarged fruiting calyx, and turned brown and fell off when a flower was allowed to wither, the calyx-lobes remaining.

While examining these plants, I came across the curious structure shown in Fig. I. in which a complete 4-merous flower bud apparently was subtended by a supernumerary calyx-lobe, in a flower exhibiting various other irregularities.

At first sight I interpreted this as a case of proliferation of the edge of the hypanthium, the pedicel of the bud in question being fused

with the calyx tube. After dissecting the flower, I found however that this explanation could hardly be correct.

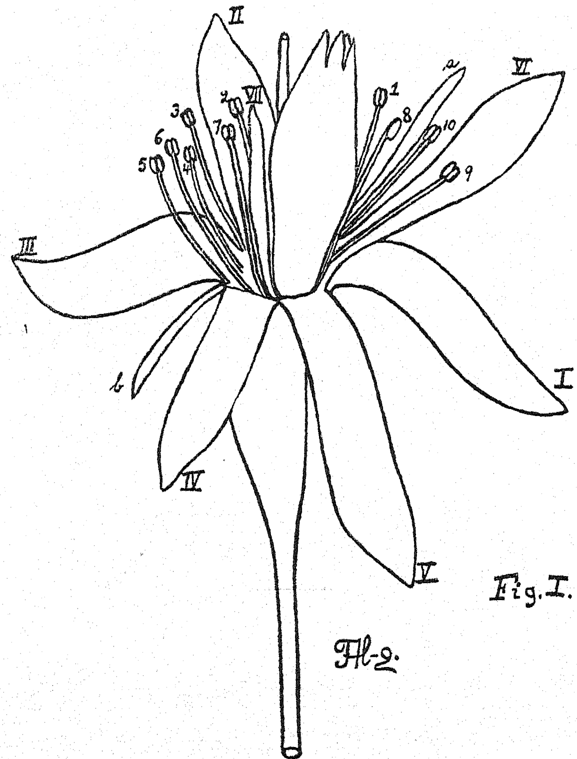

Fig. I.

Fl-2.

Abnormal flower of *Calycopteris floribunda* Lamk.

The structure is diagrammatically represented in Fig. II. The arrangement of the organs of the main flower is distinctly spiral. Apparently there are seven calyx-lobes (I-VII), the innermost subtending the bud mentioned. There are two true petals (*a*, *b*), one between the sepals I and II, the other between III and IV. The full number of stamens is present, one of the inner series (8) having an atrophied loculus. The pistil is normal.

If the above interpretation were correct, the mutual arrangement of the series of petals and stamens would be difficult to explain. The following seems much more probable.

At some early stage in the development of the inflorescence, some mechanical agency removed a flower with its bracteole (VII) from the

whorl next above that to which the main flower belonged. This may have been effected by the proboscis of some insect. The flower with its bracteole was accidentally grafted on to the calyx-tube below the inner series of stamens of the main flower. At the same time the calyx-tube was ruptured between the stamens 2 and 10 of the inner, and 1 and 9 of the outer series, as indicated by the dotted lines. Finally, the calyx-lobes I and VI are in reality parts of the same initial lobe. This explains the normal position of the petal *a* and the stamen 1 with regard to the smaller part I, and of the stamens 9 and 10 with regard to the larger part VI. As the wound healed, the displacements indicated took place, causing the falsely spiral arrangement.

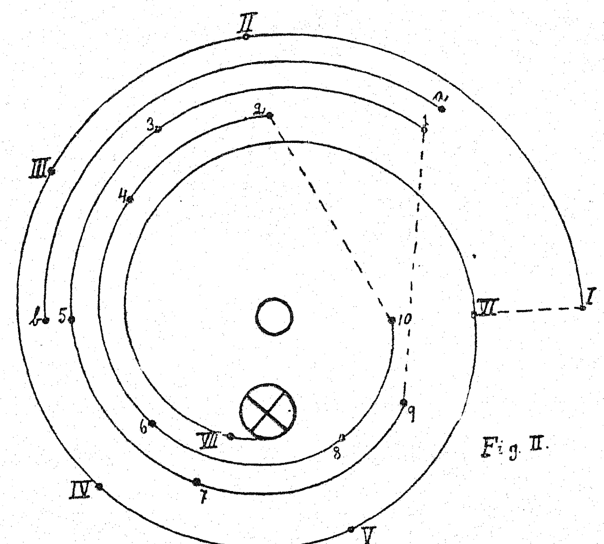

Fig. II.

Diagram of abnormal flower of *Calycopteris floribunda* Lamk.

Various other abnormalities of the calyx of other flowers were observed. Thus, the flowers of terminal whorls often had two lobes partially united in various degrees. Also supernumerary calyx-lobes, smaller than the normal ones, were occasionally noted.

II

On some abnormal flowers of **Habenaria grandiflora** Lindl.

This Orchid abounds on the open grassy spots round Khandala railway station (G.I.P.) on the Western Ghats, in the beginning of

the rainy season, before the grass has time to attain any consider height. Here the specimens described below were collected. plant has a solitary, radical, sub-orbicular leaf and a short scape, ing one to four flowers. The petals are normally obliquely bipar with a broad upper and a filiform lower segment. The lip is tripar with a linear-lanceolate middle lobe and filiform lateral segments. spur is longer than the ovary.

(1) *On a case of perfect pelory in* **Habenaria grandifl** Lindl.

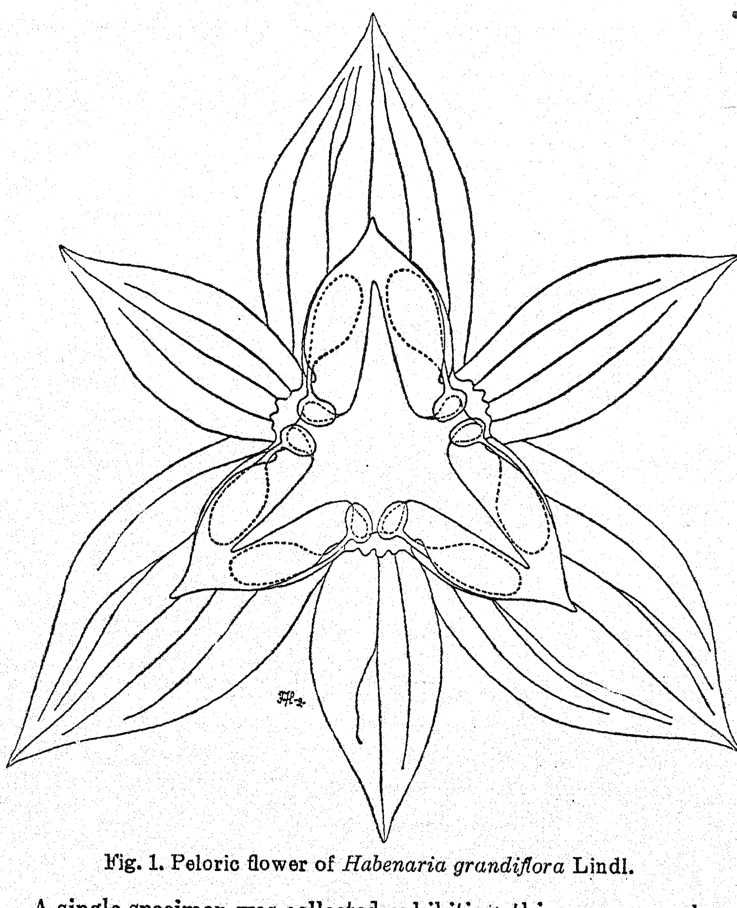

Fig. 1. Peloric flower of *Habenaria grandiflora* Lindl.

A single specimen was collected exhibiting this very rare phenomenon (Fig. 1).

The flower opens straight upwards, not outwards, as is normally the case in species of this genus, where the ovary is bent or twisted

in order to effect the position indicated. The scape is scaleless, and bears only the peloric flower, but opposite the normal bract there is a short undeveloped branchlet.

As may be seen from the figure, the three sepals are undistinguishable from one another, except for irregularities in the nervation, which shows various transition forms between the 5-and 7-nerved types (the latter being the normal one in the species). The three petals are also alike, 3-nerved, ovate-lanceolate, acute. There are thus no traces of the filiform segments of the normal petals, or of the lobes of the normal lip, and its long spur.

The outer whorl of stamens is fully represented by three complete anthers, each with its two pollinia. The inner whorl is represented by three fleshy, granular staminodes (visible at the base of the petals in the figure). All these structures are morphologically normal.

The stigma is a triangular structure with a depression in the centre. Each vertex of the triangle forms a rostellum, normal in shape. Along each side, on a protuberance, are two pockets, in each of which a gland of a pollinium is resting.

The clavate "stigmatic" processes, conspicuous in the normal flower (see either of the columns in Fig. 2), are here totally absent. From their normal position it seems to me probable, that they have to be regarded as the two reduced stamens of the outer whorl. But they may of course acquire a stigmatic surface through fusion with parts of the stigma. In our peloric flower the stigmatic surface is presumably situated in the central depression. The ovary is normal, except in showing no trace of bending or twisting.

As far as I am aware, only a single equally perfectly peloric Orchid flower has ever been described. [See: Schlechter & Fischer—"Pelorische Blütenbildiug bei *Odontoglossum grande* Lindl." Orchis (Beil, z. Gartenfl.), Jahrg. V (1911), pp. 119—122. Also: Worsdell, W. C. —"The Principles of Plant-Teratology," vol. II, pp. 82, 94; Pl. XXXVII, Figs. 5, 6.]

(2) *On two cases of synanthy in* **Habenaria grandiflora** Lindl.

A. In one of the specimens in question, the scape bears only the dual structure shown in Fig. 2. It is subtended by a bract with two strong midribs, symmetrically placed, and rather far apart. There are two fainter lateral nerves, one on each side. The tip of the double bract is missing. Opposite to the bract, there is a short undeveloped branchlet.

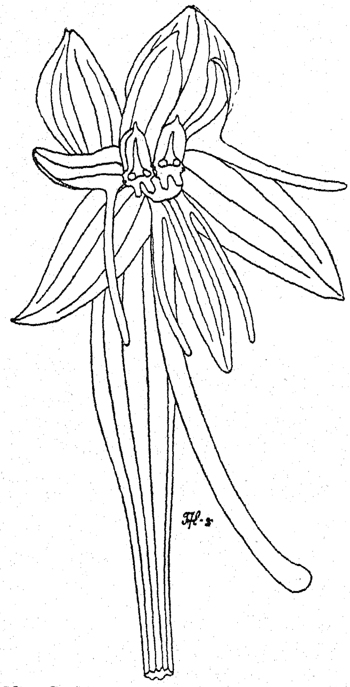

Fig. 2. Two concrescent flowers of *Habenaria grandiflora* Lindl.

The most noticeable feature of the double structure is the presence of two complete, normal columns, placed side by side, and separated by a two-nerved sepal, apparently a reduced lateral sepal belonging to the flower on the right. Both dorsal sepals are present, the one to the right being 7-nerved, the other 5-nerved. The two outer lateral sepals are both 3-nerved, and well developed. The two outer petals are nearly normal, 2-nerved. There is no trace of the inner pair of petals. There is only one lip and spur, whether a double structure or not cannot be made out. The opening to the spur is unusually wide. The ovary (Fig. 3) consists of four carpels, one pair of which is better developed than the other.

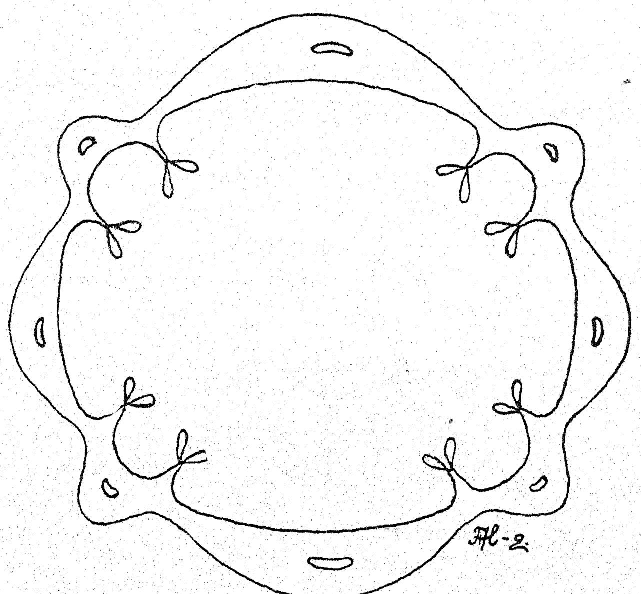

Fig. 3. Diagram of ovary common to the flowers of Fig. 2.

B. In the other case under notice, the synanthy is less complete, being confined to the ovaries of the flowers concerned (Fig. 4).

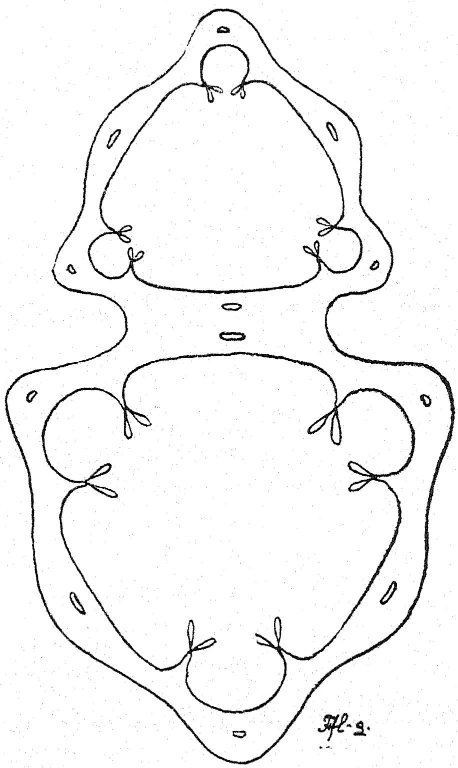

Fig. 4. Diagram of two fused ovaries of *Habenaria grandiflora* Lindl.

In addition to the double structure, the raceme consists of two normal flowers lower down on the scape. The double bract is bicuspidate, with one strong nerve to each tip, and two faint lateral ones on each side. Opposite this bract, there is a small undeveloped branchlet.

As may be seen from the cross-section, which is taken near the widest part of the double ovary, the fusion takes place along the back of two carpels. The contracted tips of the individual ovaries are free, and the flowers are otherwise quite nomal.

(3) *On two cases of fusion of the lateral sepals, accompanied by reduction of labellum and suppression of spur in* **Habenaria grandiflora** Lindl.

A. In the first case (Fig. 5) the two lateral sepals have fused to form a boat-shaped structure not unlike the normal dorsal sepal. There are, however two strong midribs, each ending in a small cusp. Another fainter nerve ends in the sinus between the cusps. It probably represents two lateral nerves. In addition, there are two lateral nerves on each side.

The labellum is reduced to a linear acute 1-nerved structure of about the same length as the sepals. The spur has entirely disappeared.

The remainder of the flower is normal.

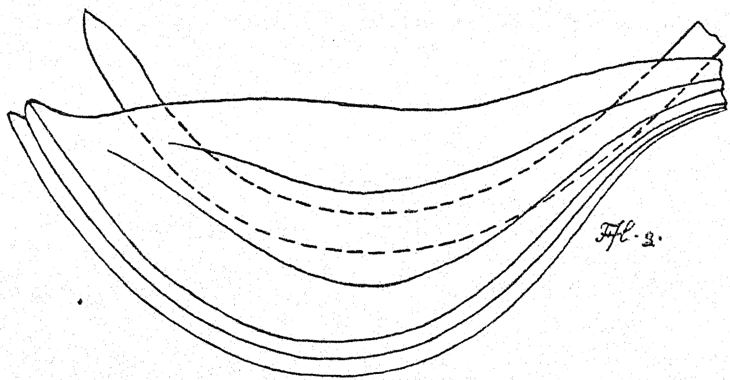

Fig. 5. Fusion of lateral sepals and reduction of lip in *Habenaria grandiflora* Lindl.

B. In the second case of fusion of the laterel sepals, the resulting double structure cannot be distinguished from the dorsal sepal, except by its being 7-nerved, the latter being 5-nerved. Here the lip is reduced to a small fleshy process, rather like a "stigmatic" lobe in a normal flower, although about twice as long. As in the last case, there is no trace of a spur. The stigmatic lobes are also totally absent. Instead, the basal lobes of the rostellum are considerably larger than usual, whether due to mere over-development or to fusion with stigmatic parts not being apparent.

(For another abnormality in the same specimen, see next section.)

(4) *On a case of laminar outgrowths from the midrib of a double bract in* **Habenaria grandiflora** Lindl.

The abnormal flower described in section (3) B. has its pedicel fused with that of another, normal flower, the two flowers being the only ones on the scape, and subtended by an interesting double bract (Fig, 6). The constituents are fused along the midribs of their dorsal

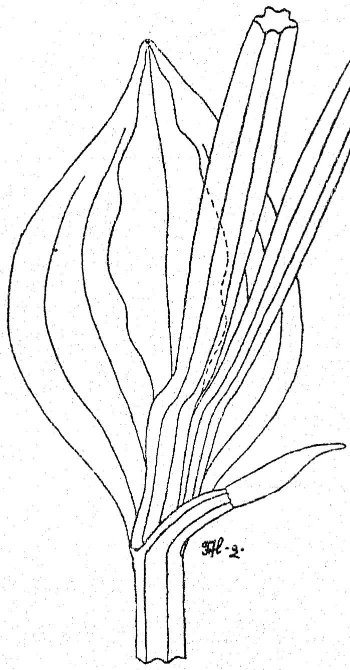

Fig. 6. Laminar outgrowths in a double bract of *Habenaria grandiflora* Lindl

surfaces. The two leaf-halves, nearest the flowers, are reduced, and devoid of nerves. Their dorsal surfaces are fused in their lower third parts to the pedicel of the normal flower. The other two leaf-halves are well developed, each with two lateral nerves, and the fusion is so perfect, that if the reduced pair were absent, the structure would be morphologically undistinguishable from a normal bract. Opposite the double bract, there is a small undeveloped branchlet, representing the displaced main part of the scape.

SMUT (USTILAGO PARADOXA *Syd. and Butl.*) ON SAWN (PANICUM FRUMENTACEUM *Roxb.*)

BY

G. S. KULKARNI, M.A.G.,

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The discovery of this smut, in 1919, on Sawn or Banti so far as the writer is aware is the first record of its occurrence in the Bombay Presidency. It was collected by the writer in Sind where he noticed it occurring quite commonly and at certain places doing great damage. It has not been found in the Presidency proper. Outside the Presidency it has been recorded only from Pusa. Butler* gives a short description of this smut in his book. The specimen agrees in every respect with his description. The attack of the fungus is confined to the ears in the plants. The sori which are round and hairy are developed in the ovary and are a little bit bigger than the normal grains. The hard coating of the sorus on rupture liberates black powdery spores which are round or oval and measure from 7 to 10 μ in diameter. The spores on germination in water produce only long septate germ tubes. But in the nutritive solution (tomato broth) the author has noticed the germination by forming a promycelium and sporidia which bud freely and produce abundant secondary sporidia. Butler recommends no treatment for this smut since its life-history is unknown. The author was therefore interested in the study of the life-history of this uninvestigated smut. Experiments were made to see whether the fungus was seed-borne in its infection and if so any ordinary seed treatment would check it. The following are the details of the experiments.

A small quantity of Sawn seed sufficient to sow a 4-guntha plot was infected with spores of the smut. Infection was done by dusting the spores on the seed. The seed was then divided into two lots. One lot was steeped in a solution of 2 % copper sulphate for 10 minutes. The seed of each lot was sown separately.

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* Butler E. J., Fungi and Disease in Plants, page 239.

The plants were raised to maturity with the results shown below :—

Experiment No.	Place.	Attack in the		Remarks.
		infected seed.	treated seed.	
1	Mirpurkhas Farm (Sind) ...	Mostly all plants infected.	Nil.	90% showed smut attack.
2	Agricultural College Farm, Poona.	Do.	Do.	Do.

The results of these experiments show that infection of the plant takes place in its seedling stage with the seed-borne spores and it can be prevented by steeping the seed for 10 minutes in 2 per cent. copper sulphate solution.

THE INDIAN SPECIES OF ERIOCAULON

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(*Continued from Vol. II, p. 320.*)

VII. CONNATO-SEPALAE.

Sepals of the female flower united as a calyx opening at the back, as in the males of most other species. Petals distinctly clawed, glabrous or hairy, with a gland inserted close inside the apical margin. Scapes usually (? always) many. Receptacle more or less hairy. Male flowers similar to other sections with black anthers.

Species about 10, nearly all in Japan or China, one Himalayan and possibly one in Brazil.

45. **E. alpestre** Hooker et Thomson. (H. and T. coll. No. 58 in Herb. Calc. !); F.B.I. vi 578, No. 23; Ruhl. No. 148. Stem short, leaves flat, tapering to a fine point, from 1/2 in. to 3 or 4 in. in vigorous specimens. Scapes numerous, slender. Involucral bracts glabrous, pale obtuse, shorter than the floral. Receptacle convex, glabrous. Female flowers :—Calyx spatheaceous, but showing partial division into three sepals. Claws of the petals nearly as long as the blades; glands terminal. Male flowers :—Corolla lobes small, anthers black. Seeds oblong, light brown. Plate 42.

Himalayas; Kumaon 3—4,000 ft. Sikkim 8—13,000 ft; Khasia 5,000 ft.

The connate sepals of the female flower mark this species as quite distinct from all other Indian ones, while the short rounded involucral bracts, the clawed petals and very densely tufted habit, though not unique, are very characteristic.

VIII. LEUCANTHERAE.

The anthers are yellow or white. Most of the species have the long narrow leaves of plants submerged in running water, but except that the female petals are rather broader and almost spathulate, nothing beside the anthers distinguish this group from the SIMPLICES sub-sect (*a*) (Vol. 1, p. 195.) Stems may be short or elongated. Heads 1/6-1/2 in.; involucral bracts pale or edged with black; receptacle glabrous. Floral bracts usually black, but covered with white hairs, which make the heads grey or white.

About 15 species, 5 African, 9 Indian, 1 Chinese.

Two Indian species given by Ruhland as having white or yellow anthers, which I have not seen are distinguished by him as follows :—

Sheath truncate, the mouth nearly entire ... E. melaleucum *Mart.*
Mouth of the sheath oblique, leaves 6-10 in. peduncle solitary 4-6 cm. ... E. Ritchieanum *Ruhl.*

The *E. melaleucum* of Hooker's F. B. I may possibly have been a different plant from that taken by Ruhland, for Hooker described the receptacle as glabrous, and the female petals as without glands, while Ruhland described the receptacle as hairy, the petals as with glands. Martius in Wall Pl. As. Rar iii p. 29 described the anthers as "flavescentes tandem nigrescantes." Koerniche who gives a very full description omits mention of the receptacle (see note in Appendix I).

The Indian species are here arranged in order of progressive lengthening of the leaves, which in the last species but one are threadlike in conformity with a habit at in running water. The last species is a land plant with short acicular leaves.

TABLE OF PROBABLE RELATIONSHIPS.

—*var* mitophyllum	...	Khasia.
miserum	...	Silhet
fluvatile	...	Ceylon.
—horsley-kundae	...	Cuddappah.
breviscapon	...	Kanara.
rivulare	...	Kanara.
—Sieboldianum	...	Wide.

Key to the Leucantherae.

* Plants of marshy ground, leaves short.
Scapes 6-10 in., heads 1/3-1/2 in. ... 46 E. horsley-kundae.
Scapes 2-5 in., heads 1/10-1/6 in. ... 51 E. Sieboldianum.
** Plants of running water, leaves linear ...
† Leaves 1/10-1/6 in. wide, involucre black (Kanara) ... 47 E. breviscapon.
†† Leaves less than 1/10 in. ...
Involucre pale (Kanara) ... 48 E. rivulare.
Involucre black (Khasia) ... 49 E. miserum.
„ „ (Kanara and Ceylon) ... 50 E. fluvatile.

46. **E. horsley-kundae** Fyson, sp. nov. (Gamble No. 20985 in Herb. Calc. ! Caulis perbrevis. Folia 3-5 cm. plana, basi 3mm. lata

ad apicem sensim angustiora. Pedunculi 15-24 cm., a glabri; vaginae 5 cm., ore acutae. Capitula 6 mm. lata, globosa, nigronivea. Receptaculum glabrum. Flores trimeres. Flos ♀:—petala externe visiblia, magnis nigris glandulis instructa. Flos ♂; sepala ad spatham antice fissam connata. Petala æqualia. Anthrae albae. Plate 43.

Peninsular India; Panchgani, N. Kanara. Horsley-Kunda in Cuddappa District.

Scapes and leaves rather flaccid. Leaves very short compared with the scapes, otherwise the plants with the habit in general of *E. collinum* Hook f. Heads rather small. floral bracts black, but covered with white hairs. Receptacle glabrous. Flowers 3-merous, normal but anthers white.

Var. megalocephala. Capitula valde majora, 8-12 mm. lata.; pedunculi breviores, 8-12 cm. Plate 44.

Central Provinces, Mandla District, Peninsular India, Mysore, Nilgiris 5,000 ft.

Peduncles much shorter and heads larger, possibly a distinct species. In habit like *E. Geoffreyi*, of which it might almost be thought to be a white anthered variety.

See App. I. E. Ritchieanum and E. melaleucum.

47. **E. breviscapon** Koern.; F. B. I. vi 575, No. 16; Ruhl. No. 78. Stem short. Leaveswith broad sheathing base, then suddenly narrowed to a long linear blade, about 1/6 in. by 8-10 in. Scapes a little longer. Heads 1/3-1/2 in. Involucre black, or the outer bracts pale, reflexed. Plate 45.

Peninsular India; N. Kanara, in streams, etc. at 2,000 ft.

48. **E. rivulare** Dalziel; F.B.I. vi 580, No. 30 (E. Dalzeli); Ruhl. No. 138. Stem a few inches or 0, thickly covered with the very numerous leaves. Leaves linear, barely 1/12 in. wide not much enlarged at the base, 4 to 9 in. long. Scapes numerous, to 13 in. in length. Involucral bracts pale, at length slightly reflexed. One male petal longer than the others. Plate 46.

Peninsular India; on the Ghats, at Castle Rock, etc. in streams.

A close connection of the last species of which it may be regarded as the more pronounced aquatic form.

Koerniche l.c. p. 605, rejected Dalziel's name *rivulare* because of a plant of West Africa so named previously by Don. But Ruhland identifying Don's plant with a still earlier *E. latifolium* Sm. restored Dalziel's name.

49. **E. miserum** Koern. (Wall. Cat. 6070 in Herb. Calc.!); F.B.I. vi 575, No. 19; Ruhl. No. 72. Stem 1/6 in. thick, up to $1\frac{1}{4}$ in. long branched at the base and so tufted, clothed below by the numerous filiform dead leaves. Leaves sheathing at the base, but soon

narrowed to the linear blade, 2-6 in. long. Peduncles 6-10 in. Heads 1/12-1/2 in., diam., few flowered. Involucre obtuse, black, horizontal. Receptacle glabrous tall. Female flowers normal. Anthers of male yellow. Plate 47.

Assam; Silhet.

Var. mitophyllum Hook f. (Clarke 18270 Jaintea at 4,000 ft. in Herb. Calc. !). F.B.I. vi 575, No. 13; Ruhl. No. 70 (as distinct species). Leaves longer and about 1/20 in. wide. Heads larger 1/6 in. A robuster plant. Plate 48.

Assam; Khasia Hills, Jaintea, Goalpura.

Hooker in founding this as a species says it might be a form of *E. miserum*, but for the leaf-sheaths being larger and the receptacle globose not columnar. Ruhland says of *E. miserum* that well developed flowers had not been seen by Koerniche (the founder). Though I do not find this stated in Koerniche's description in Linnaea l.c. having regard to the variability of submerged plants I feel this is almost certainly a robust form of *E. miserum*. The two occur in the same locality, but whether together or at different levels the sheets do not indicate.

50. **E. fluvatile** Trimen; F.B.I. vi 581, "imperfectly known"; Ruhl. l.c. p. 115 "ignota"; but probably E. Barbeyanum Ruhl. n. sp. Plate 49.

Stem short, densely tufted. Leaves linear from a base 1/8 in. wide, very slender, solid and channelled above, drying black. Scapes several, up to 15 in. Heads 1/4 in. Involucral bracts pale edged with white, reflexed so that the head is globular. Flowers normal, but anthers yellow. Seeds round, reddish yellow.

Peninsular India; N. Kanara in running water; Ceylon.

These last three species are progressively more pronounced running water forms. The Kanara sheet of the last in Herb. Calc. is of a sturdier plant than the Ceylon, one, but this is probably only a chance difference. One Ceylon sheet marked "still water form" has the leaves of E. rivulare, and heads intemediate in size between the two species. Ruhlands *E. Barbeyanum* is I think this species.

51, **E. sieboldianum** Sieb et Zucc; F.B.I. vi 577, No. 21; Ruhl. No. 191,192. Stem 0, Leaves 1-2—2 in., acute. Scapes $1\frac{1}{2}$—5 in., Slender. Heads 1/10-1/6 in., ovate or conical. Involucral bracts obtuse, short. Floral oblong-acute, pale or dark, but usually with a dark central band and narrow scarious margins. Male flowers perfect, calyx limb ovate acute, black upwards, anthers white. Female sepals 3-2-0 narrow; petals 0. Receptacle with a few hairs. Plates 50 and 51.

Widely distributed in India, China and Japan. In South India on damp sandy soil.

This appears to be a much reduced land-form of this group. Though the scarious floral bracts might lead one at first to suspect an alliance with the

"SCARIOSÆ", the dark distinctive band present in nearly all heads, is probably derived from the dark bracts of the others of this group. In the fresh state this is more conspicuous on the lower floral bracts giving them a brownish tinge. The black calyx limbs appear as black spots among this white glistering bracts of the upper flowers.

Ruhland divides the species as defined above into four species according to the distribution and the development of female sepals, and calls some of the Indian forms *E. redactum*, as having only 2 or 3 minute female sepals. This separation of the species involves very careful dissectum under a high powered lens, and since as explained in the introduction, it is clear that in the genus Eriocaulon the flowers are highly plastic, and moreover the female sepals of this species are so quickly caducous that it is impossible in seeding heads to be certain of their number, every object of systematic botany would appear to be best served by considering these forms as variations of one widely distributed species.

APPENDIX I.

Species not seen or identified by me.

The following species given in Ruhland's monograph or elsewhere, some of them as "dubiae vel imperfecte cognitae", have not been seen and are unknown to me.

E. Ritchieanum Ruhl. No. 84. Stem 0. leaves linear acuminate, thin, 4-7 nerved, glabrous 4-5 cm. long, 1·3 mm. wide at the middle. Peduncles solitary, 16 cm. long, compressed when dry. Head 4-5 mm. broad, villously white. Involucral bracts obtuse, glabrous; floral similar, yellowish black, puberous at the back. Sepals and petals 3 each. Anthers white.

Belgaum Ritchie 1248 in Herb. Bois-Bar. (This may be my *E. horseleykundae* (No. 46) in which case the latter name will not hold.

E. pseudo-quinquangulare Ruhl. No. 86. Stem 0. Leaves 5-8 cm. long. Peduncles 10-23 cm. Heads 3 mm. wide. Floral bracts oblong-obovate, acuminate, blackish, hairy at the back. Sepals and petals 3 each; female sepals obovate-acute, crested. Anthers black.

In the Botanic Gardens Sharampur.

E. heterolepis Steud. Steud. Syn. Pl. Cyp. p. 271. Ruhl. No. 87. Stem 0. Leaves 5 cm. long, lanceolate obtuse from a broader base, 9-11 nerved. Peduncles very many, 13 cm. high. Involuoral bracts scarious, 2 seriate; outer deciduous the inner shorter than the others. Floral bracts olive-green, densely hairy. Sepals and petals 3; female sepals with crest, one a little shorter than the others, and narrow linear.

Bombay (Raux, Steude and Korniche).

Strndel l.c. described the sepals as linear, not mentioning any crest. Koerniche l.c. p. 652 wrote "Planta mihi valde dubia, an mutato nomine jam descripta?"

E. pectinatum Ruhl n. sp. No. 121. Stem 0, Leaves 1—1·6 cm. long. Peduncles solitary 5-6 cm. Head villously white, 4-5 mm. broad. Involucral bracts broadly obovate, acute, glabrous, yellow always conspicuous. Floral bracts obovate, cuspidate keeled, pilose on the back at the apex. Sepals and petals 3, one male petal much longer than others. Anthers black.

Nilgherries (Perrottet, 1167).

The solitary scapes make it possible that this is the species which I named *E. Geoffreyi*, (No. 3), in which case of course the latter name must go.

E. Bombayanum Ruhl. n. sp. No. 169. Stem 0, Leaves linear. lanceolate, acute, 1.5—2 cm. Peduncles numerous, 8-10 cm. Heads densely white, puberous. Involucral bracts greenish, glabrous, conspicuous. Floral olive black, oblong-obovate, acute. Sepal 2 only in both sexes. Petals 3 ; female petals linear oblanceolate, ciliate, Anthers black.

Bombay (Warburg 867 in Herb. Berol). Possibly my E. Thomasi (No. 44) is this, but no mention is made of the very striking inflation of the peduncle just below the head. (But see E. Neesianum *Koern.* below).

E. eurypeplon Koern. Ruhl. No. 170; F.B.I. vi 585, "imperfecte cognita." Stem 0. Leaves 3-9 cm. long. Peduncles crowded 15-25 cm., 4 winged. Heads subglobose 3-4 mm. diam. Involucral bracts very broadly ovate acute, olive brown, puberous on the back. Floral bracts rhombo-cuneate, acuminate. Receptacle villous, Sepals of both sexes 2 ; petals 3. Male sepals emargineto-truncate at the apex with winged keel. Anthers black. Female sepals deeply concave, crested on the keel : petals without glands.

Malabar, Concan, etc. (Stocks, Huegal).

I cannot trace this at all, the emarginate truncate male sepals seem like that of *E. truncatum* Ham. The only sheet in Herb Calc. bearing this name was collected by Clarke in Dhaka and is I consider *E. truncatum*.

E. minimum Lamk. Ruhl. No. 182, F.B.I. No. 585 "imperfecte cognita." Leaves $2\frac{1}{2}$ cm. Peduncles $2\frac{1}{2}$-5 cm. Involucral. bracts obtuse, straw-coloured, glabrous. Floral similar. Sepals of both sexes 2; petals 3. Male sepals falcate, irregularly toothed, glabrous ; female sepals, similar. Anthers black.

East Indies (Sonnerat in Herb. Lamarch, Roeper).

Koerniche, Linnæa xxvii. p. 635, placed this closest to *E. truncatum* Han, and suggested that it is a form of it : and I think so too. Hooker in F. B. I., preferred *E. Sieboldianum* as its nearest ally, but the black anthers sufficiently distinguish it. Ruhland had not seen a specimen.

E. glaucum Griff. Not. III, 113 ; Ruhl and l.c.p. 115 as "imperfecte cognita."

E. Rouxianum Steud. Steudel Syn Pl. Cyp. p. 271; Ruhl. p. 116, "imperfecte cognita" Leaves linaar-lanceolate from a broad base, 1—1½ in. Head ⅛ in. diam. Involucral bracts, herbaceous, erect, linear-oblong obtuse, 1/4 longer than the white villous head. Floral bracts, obovate-obtuse, ciliate. Sepals lanceolate, ciliate at the apex.

Near Bombay.

Ruhland remarks that Koerniche thinks that is *E. Thwaitesii*, but he himself thinks this very doubtful. Putting aside the herbaceous character of the involucral bracts, their length suggests my *E Dianæ*, but the description does not suffice for more,

E. melaleucum Mart. Wall Pl. As. Rar. III p. 29; F.B.I. vi 574; Ruhl. No. 80. An annual (*Mart*). Leaves 1-2 in. 3-7 nerved linear subulate or accuminate. Sheaths twice as long, truncate. Peduncles solitary or few, 3-6 in. high. Involucral bracts black, obtuse; floral acuminate, black, thickly bearded. Sepals and petals 3 each. Female sepals 2 boat shaped 1 flat; petals oblanceolate, ciliate. One male petals slightly longer than the others. Anthers globose, yellow but turning blackish, "Flavescentes tandem nigricantes," (*Mart*). Seeds elliptic. S. India—Coramandel (Mart. Wall Cat. 6080.)

F.B.I. gives Nilgiris (Heyne and Schmidt) and Arrakan (King). Ruhland quote also Perrottet 1166 (Nilgiris) and Wight 2856.

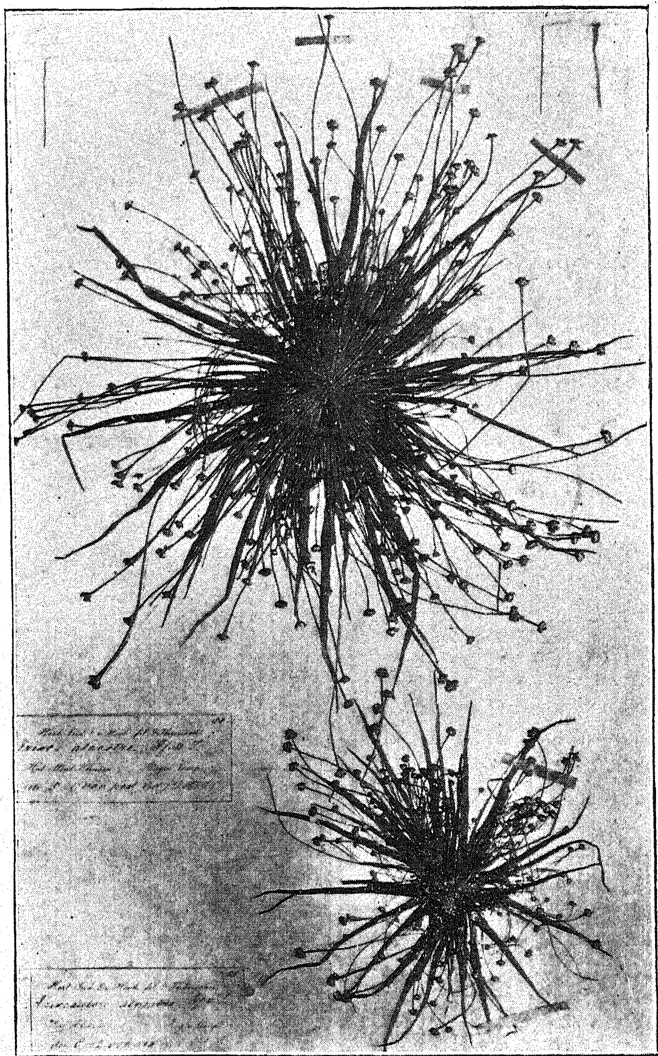
Inspite of the wide range attributed to the species there is no sheet with this name in the Calcutta Herbarium. But this very wide distribution, from Burma to the Coromandel, and from the plains to the Nilgiris suggests a mixture of more than one species. The blackening of the yellow anthers is also strange. Martius, plant may be my *E. horsley-kundæ*, but I have not had access to Wallich's collection, and this latter species has not a markedly truncate sheath. On the other hand *E. collinum* Hook f. on the Nilgiris often has, but its anthers are black, and except by the anthers which were not noticed by Hooker, it is easy to confuse *E. collinum* what I call *E. horsley-kundae* with var *megalocephala*, (No. 46), for both grow on the Nilgiris at 5,000 ft.

E. subglaucum Ruhl., Ruhl. No. 68. This name Ruhland gave to the plant named by Thwaites' *E. atratum* var. *major*, (No. 61,) which Hooker reduced in Trimens Flora of Ceylon to *E. zeylanicum* Koerniche. But see my note on *E. atratum*, (No. 30).

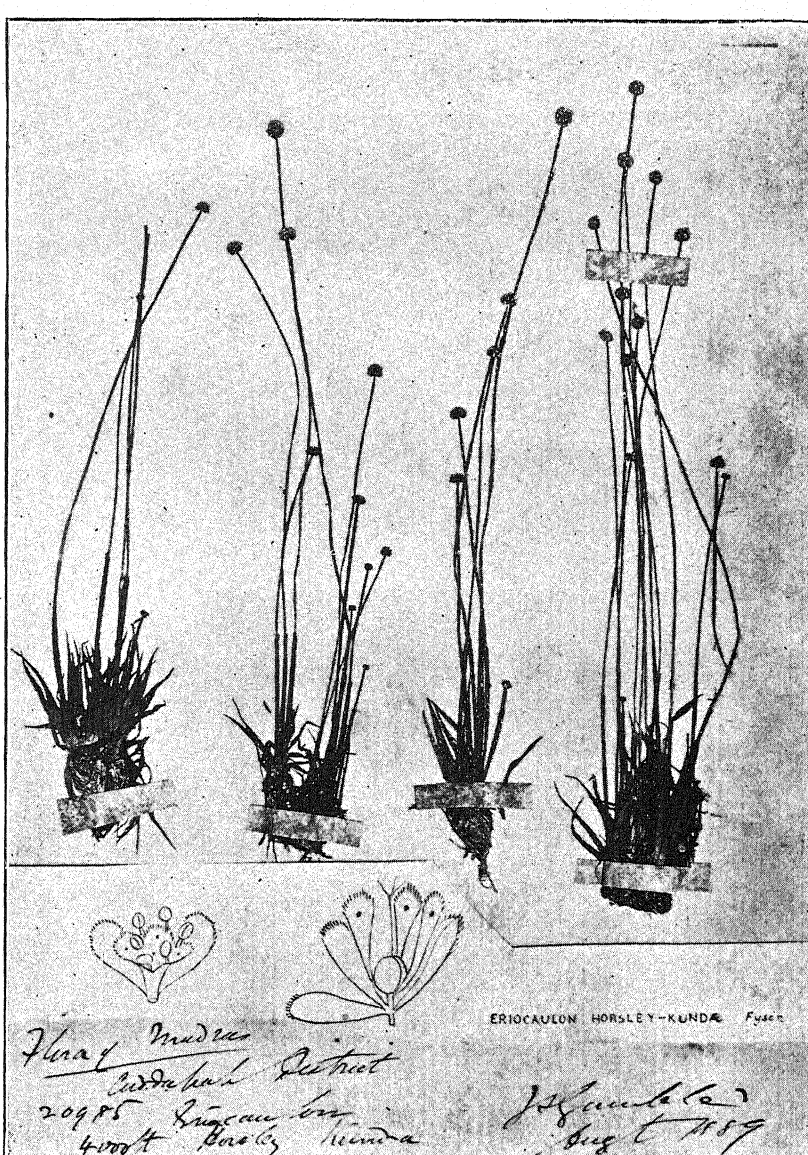
E. Neesianum. Koerniche; Ruhl. No. 172. Very similar to *E. Thwaitesii* Koern. but the involucral bract not longer than the head.

But in Koerinche's description in Linnaea xxvii, p. 630, the female sepals were given "as naviculari-carinatae et spongiosa-alatae," and the nearest alliesas *E. truncatum* Mart. and *E. achiton*. The spongey winged sepals point to my *E. Thomasi*, but the heads are described as obconic when young, and no mention is made of the prominently thickened peduncle just below the head. It is in probably the small form of *E. Thwaitesii* Koern. which I named *E. Mariae* (Fl. Nil. and Pul. H. T. t. 277). See note on No. 14.

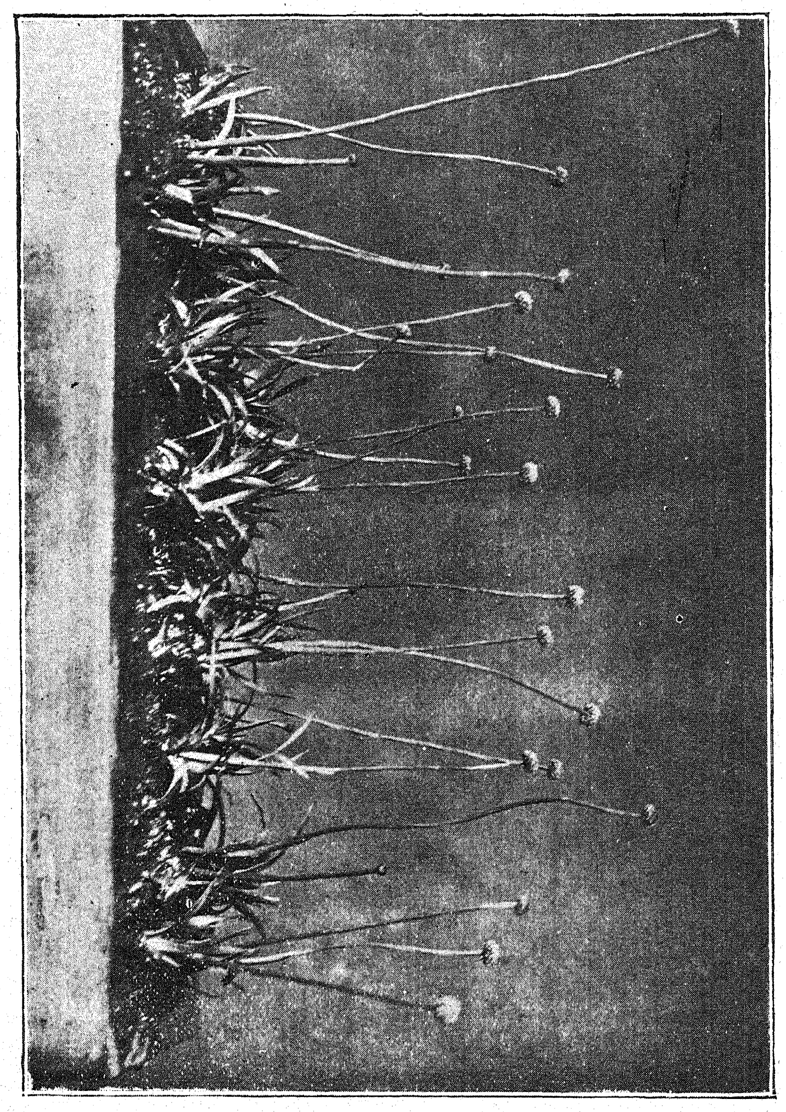
(*To be Continued*)



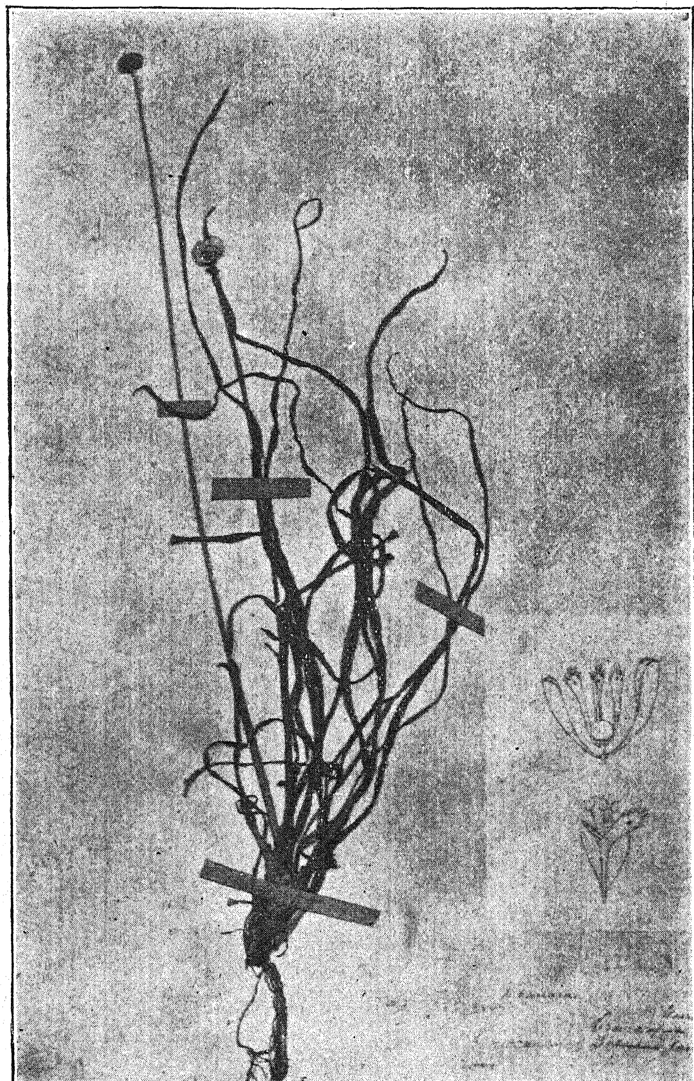
ERIOCAULON ALPESTRE *Hook. et Thomson.*



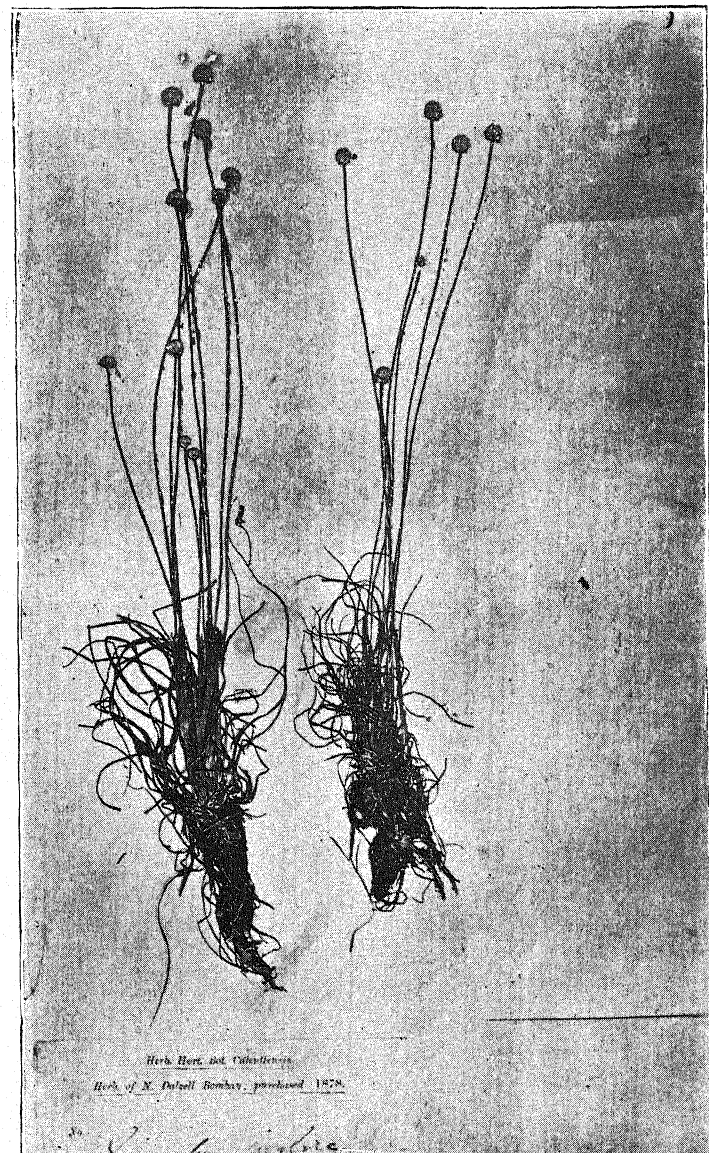
ERIOCAULON HORSLEY-KUNDÆ *Fyson.*



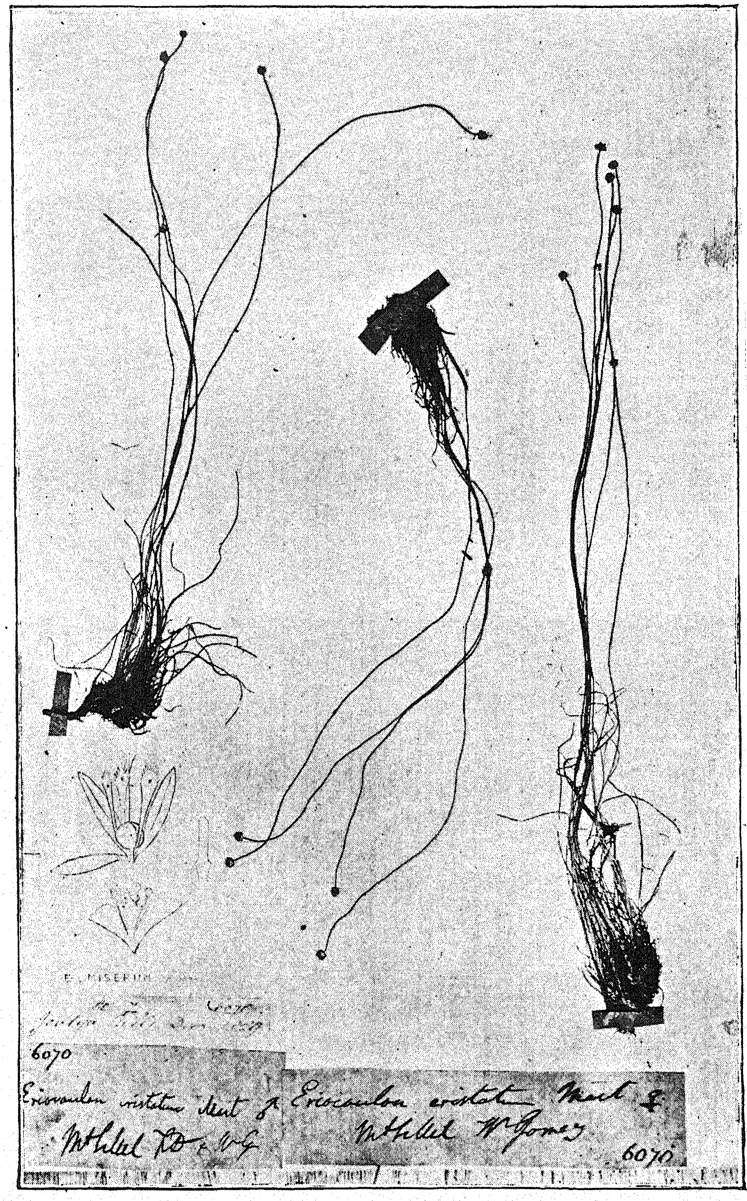
ERIOCAULON HORSLEY-KUNDÆ · *Fyson.*
Var *megalocephala.*



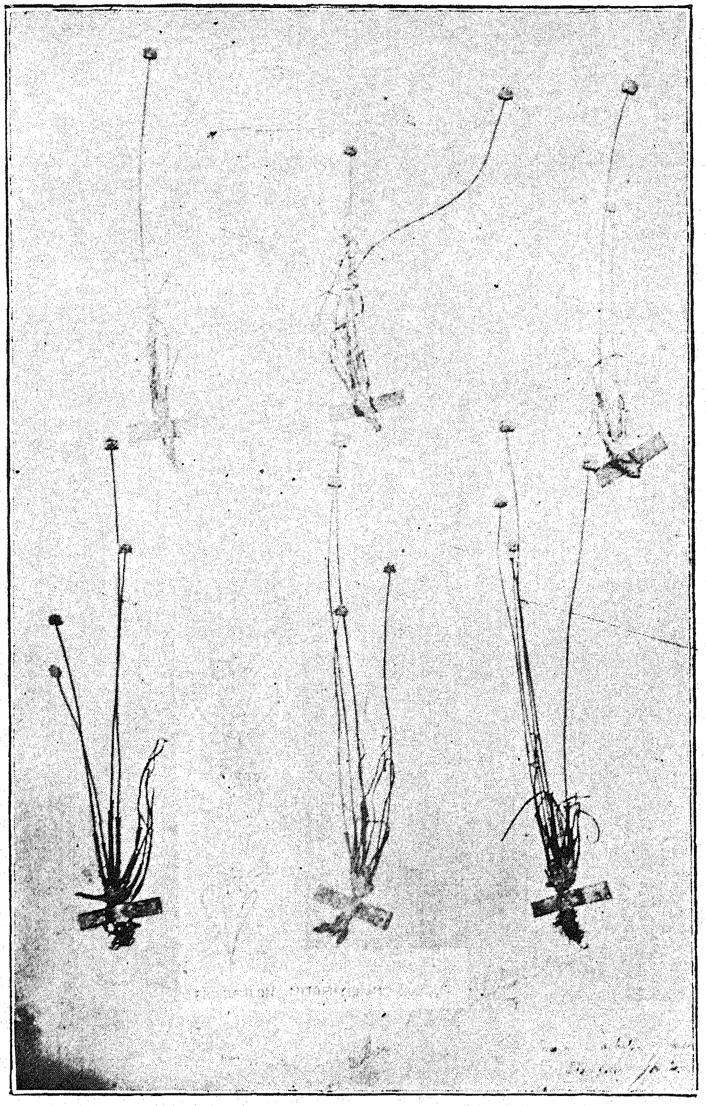
ERIOCAULON BREVISCAPON *Koern.*



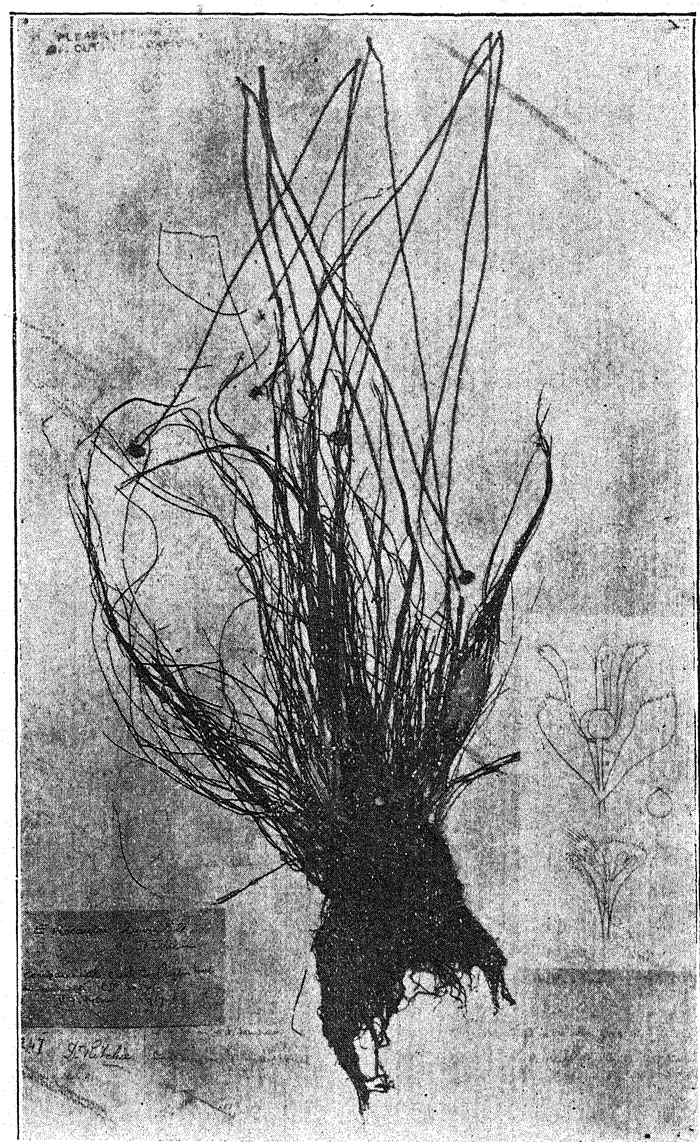
ERIOCAULON RIVULARE *Dalz.*



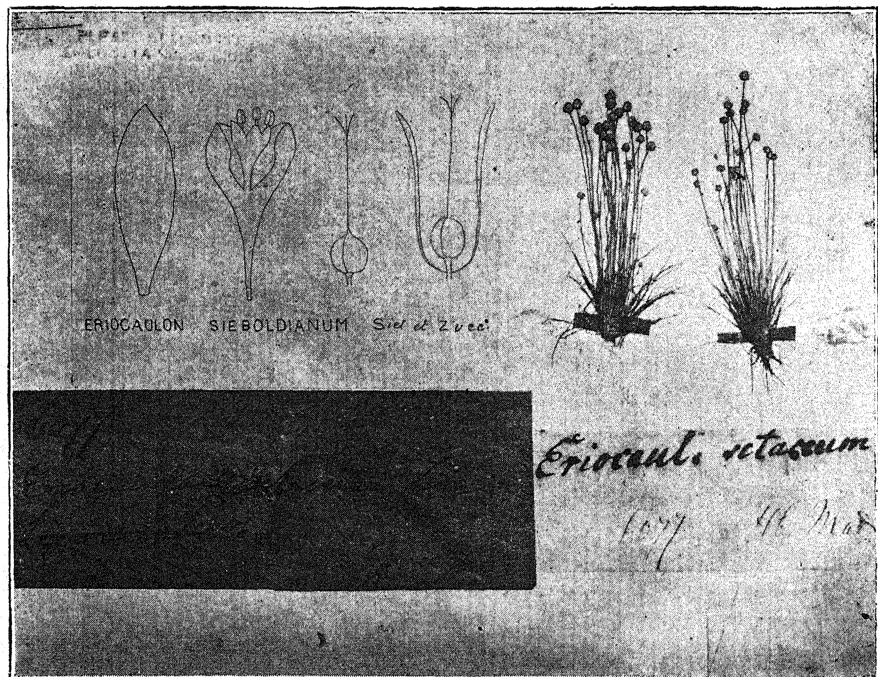
ERIOCAULON MISERUM *Koern.*



ERIOCAULON MISERUM *Koern.*
Var *mitophyllum.*



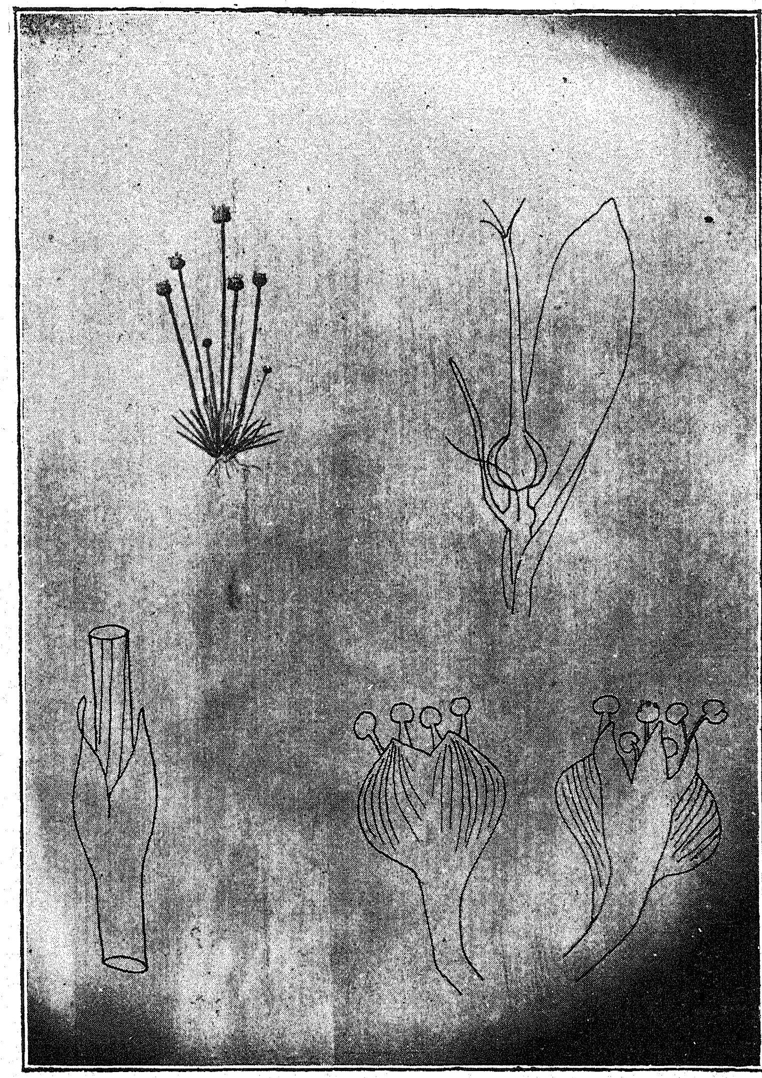
ERIOCAULON FLUVATILE *Trimen.*



ERIOCAULON SIEBOLDIANUM *Sieb. et Zucc.*

[illegible]

[illegible]



ERIOCAULON SIEBOLDIANUM *Sieb et Zucc.* *Del D. R. Fyson.*

Showing dark male calyx and great reduction in the female flower.

[illegible]

GEOGRAPHICAL DISTRIBUTION OF THE BENGAL SPECIES OF POLYPORACEAE ALONG WITH A SHORT HISTORY OF THEM IN BENGAL

BY

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The Mycological flora of such a large portion of the world remains unexplored that it is at present impossible to give a general view of the geographical distribution of fungi; even in some of the civilized countries, the phanerogamic flora of which has been fully worked out, little has been done towards the collection and publication of lists of fungi; the most we could at present is to compare the collection of one country with that of another and to note the difference and agreements. Such a comparison is useful as we learn how much there is to be known.

In case of fungi it so happens that species which were at one time very common gradually become somewhat rare and rare until they disappear altogether. The late illustrious Fries said "The fact must not be lost sight of that some species of fungi which have formerly been common in certain localities, may become within our life time more and more scarce and even altogether cease to grow there. The cause of this doubtless is the occurrence of some change in the physical constitution of a locality, such as that resulting from the destruction of a forest, or from the drainage by ditches and cuttings of more or less extensive swamps, or from the cultivation of the soil."

In case of Polyporaceae it will be seen that the geographical limits of species are not so well marked and definite as in those of phanerogamous plants. When climatic conditions regarding temperature, rain-fall, humidity, etc., are analogous, it is astonishing to find the repetition of the species in very distant parts of the globe. But it is usually found that tropical countries abounding in virgin forests form the special abode of Polipori, which grow luxuriantly under the shade affording perpetual moisture and heat. Some species are practically cosmopolitan in their range, for instance, *Fomes leucophaeus*, which was already reported from the North temperate, South

temperate, and subtropical regions, and now has been found in tropical region also (Bengal, Hooghly District). So also *Polystictus versicolor*, *Ganoderma lucidus*, and *Polyporus gilvus*, while *Fomes applanatus* is almost cosmopolitan). Others, so far as our knowledge goes, appear to have an extraordinary discontinuous distribution—for instance (1) *Polystictus protea* is found in Calcutta, Bengal, in forests near Uitenhage in South Africa and Mexico, America; (2) *Trametes lactinea* is found in Howrah District. Bengal, Ceylon, Singapur, New England, South Australia, and Cuba; (3) *Daedalea quercina* is found in Hooghly District, Bengal, Great Britain, Denmark and Paraguay (South America); (4) *Polyporus luzonensis* is found in Khulna, Chittagong, Mymensingh districts in Bengal and the Philippine Islands; (5) *Trametes occidentalis* is found in Hooghly, Howrah, Jessore and Asam in Bengal, Bombay, Mussorie, Ceylon, Malaya peninsula, Australia, the Philippine Islands, the Fiji Islands, Mauritius, Madagascar, East Africa, Guinea, South America, (Brazil and Paraguay), Central America, West Indies and United States of America. This might be due solely to our ignorance of the occurrence of obscure species in localities where they have not been properly sought for, or it may have some real significance as indicating that certain forms can not always increase and multiply even in those localities that appear most suitable for them. No generalisation however, can be reached in the present state of our knowledge of the distribution of Polypores, one is bound to wait till the fungus-flora of the whole world is fully worked out. Again there are some species of Polypores, which are strictly local within the limits of the British India (including Ceylon) and the Eastern tropics and have not up till now been found outside these limits—for instance (i) *Polystictus suboccidentalis*, was formerly reported from Bonhomme valley (India), but is now for the first time found in Hooghly district, Bengal; (ii) *Polyporus fumoso-olivaceous*—formerly reported from Ceylon only, and now found in Howrah district, Bengal; (iii) *Polystictus Berkley*, formerly reported from Ceylon only, and now found in the interior of Hooghly District, Bengal; (iv) *Merulius similis*—formerly from Ceylon, now found in the interior of the Hooghly District. So also *Fomes annularis*, *Polyporus Emerici*, *Fomes pallidus*, *Poria diversiporus*, *Polyporus secernibilis*, *Favolus scaber*, *Trametes fuscella* and *Polyporus Shorea* confined to Jalpaiguri, Buxa range and not found on plains. Lastly the discovery of some Polypores in Bengal extends the zone of distribution of our old species, for instance *Lenzites alutacea*, *Polyporus Rhizophore*, and *Polyporus anebus* were formerly recorded from the tropical region alone, now they have been found in

the sub-tropical and North temperate regions also (from 24 to 28 N. lat); similarly *Fomes leucophaeus* was formerly reported from the North temperate, the South temperate and the sub-tropical regions now it has been found also in the tropical region; *Fomes annularis* was reported from the tropics only—now found in the North temperate region (Darjeeling); *Polyporus secernibilis* was reported from the tropics only, now found in the North temperate as well (Darjeeling); *Polystictus tabacinus* was reported from the tropics and the South temperate alone, now found in the North temperate (Darjeeling) as well; *Polyporus rubidus* was reported from the tropics and the South temperate alone, now it has been found in the North temperate (Darjeeling) as well; *Daedalea flavida* was reported from the tropics and South temperate alone, now found in the North temperate (Darjeeling) as well.

History of the Bengal Polyporaceae

The work on Indian fungi has been very scrappy and at irregular intervals. The earliest record of it is to be found in Hooker's *Journal of Botany and Kew Garden Miscellany*, Vols. II, III, IV and VI. In 1850, Dr. Hooker collected a good number of different groups of fungi in Himalaya, Sikkim, Darjeeling and Khashya hills, these were all determined by Berkley and published under the heading of *Decades of Fungi* in the said volumes of the Kew Garden Miscellany. Then in 1874 stray collections of Polypores from the Calcutta Botanic Gardens and from Burma were collected by Mr. Kurz and determined by Mr. Curry and published in the *Transactions of the Linnean Society—Series Bot. Vol. I. pp. 121—126.* There were some notices of Indian fungi (mostly leaf fungi and Agaricaceae with a few Polypores) by Cooke in several scattered volumes of *Grevillea* from 1874 to 1891. In the *Kew Bulletin* from 1898—1912 George Massee named and published a few Polypores along with Agarics from Bengal, mostly collected and sent by Mr. Burkhill—the then Economic Botanist to the Government of India. Quite recently stray collections of Polypores (mainly from Darjeeling, collected by Mr. H. G. Cave, the Curator of the Lloyd Botanic Garden) have been determined and published by Mr. Lloyd of America in his Mycological Notes. This in fact represents the whole work on Bengal Polypores. From Bombay and Southern India however, a large number of Polypores with other fungi were collected by Father Blatter, Professor of Botany, St. Xavier College, Bombay and were determined by late Father Theissen, who published them in *Annales Mycologici, Vol. 9 of 1911* and *Journal of the Bombay Natural History Society 1912-1913*.

THE INDIAN BOTANICAL SOCIETY

The Madras Meeting of the Indian Botanical Society

The Indian Botanical Society grew out of a movement started at the Nagpur meeting of the Indian Science Congress in January, 1920. Invitation to membership was extended to botanists throughout India, and the organization was finally completed in December of the same year. The Society aims to unite the botanists and promote the botanical interests of India. The primary purpose is to encourage and promote research. The Society has made steady growth both in numbers and influence.

The first annual meeting was held at Madras in co-operation with the Botany Section of the Indian Science Congress. There was a short business session at the time of the Congress meeting in Calcutta the year before, but this Madras meeting was the first programme of the Society.

The entire meeting was a decided success. In addition to the programme of the Science Congress, there were special events for Society members only. On the 31st, a few members made a trip to Sripermatur to study and collect plant fossils. The next day a number of members went on a trip to Mamallapuram (Seven Pagodas), on the coast south of Madras, to study the vegetation characteristic of the region. Here a considerable variety of vegetation is met with—freshwater, brackish water, scrub forest, dune, and marine. Wild *Cycas circinalis* in the scrub forest, *Isoetes* in freshwater pools, *Eriocaulon* on damp banks, and *Spinifex squarrosus* on dune sands were perhaps the most interesting plants. It is planned to make the botanical trip a special feature of future annual meetings.

Three days were devoted to the reading and discussion of papers. The retiring President, Dr. Winfield Dudgeon, was also serving as President of the Botany Section, and the programme was made out jointly by the two organizations. Many of the papers were illustrated by lantern slides, charts and specimens.

The programme follows:

Winfield Dudgeon: The Botanical Opportunity in India (Presidential address).

Shiv Ram Kashyap and **Shiva Kant Pande** : Contribution to the life history of *Aneura indica*.

M. L. Sethi : Contributions to the life history of *Pinus longifolia.*

W. T. Saxton : Preliminary Note on the life history of *Cedrus deodara* Loud.

M. O. Parthasarathy Iyengar : Note on some attached forms of Zygnemaceae.

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M. O. Parthasarathy Iyengar : Note on some attached forms of Zygnemaceæ.

S. P. Agharkar : Abnormalities of the flower of *Musa paradisiaca* var. *sapientum* and *M. superba.*

P. M. Debbarman : A case of axial prolification of the flower of *Nymphæa rubra* Roxb ; Two new Indian plants ; Two new Assam plants.

V. N. Hate : The algal flora of Bombay Island and its immediate vicinity, the Salsette.

S. R. Bose : Geographical distribution of the Bengal species of Polyporaceæ, along with a short history of them in Bengal.

W. T. Saxton : Note on nyctinastic movements in *Indigofera gerardiana* Wall ; Note on autonomous movements in *Eleiotis sororia* DC ; Note on the rate of growth in the scape of *Hymenocallis caribæa* Herb.

B. Sahni : A note on the vegetation of Khajiar, near Chamba in the North-West Himalayas.

P. F. Fyson : The Ecology of the Nilgiri Hilltops plateau.

R. H. Dastur and W. T. Saxton : The Ecology of some plant communities in the Savannah formation.

Leslie A. Kenoyer : Notes on forest successions in the Gangetic Plain and the adjoining Vindhiyas.

R. S. Inamdar and S. P. Agharkar : Notes from a journey to Gosainthan in Nepal.

G. M. Chakradeo : An ecological study of Deccan grassland. II.

Cecil E. C. Fischer : Field notes on the Loranthaceæ of Southern India.

Shiv Ram Kashyap : Some foreign weeds recently introduced in the neighbourhood of Lahore.

K. P. Shrivastava : A note on pollination and its economic importance in some of the chief crops of the Central Provinces and Berar.

M. O. Tirunarayana Iyengar : On the biology of the flowers of *Monochoria*.

P. M. Debbarman : A short note on the short-cut to the nectar in the flower of *Castanospermum australe* C. & F.; Some observations on the anchoring pads of *Gymnopetalum cochinchinense* Kurz. and some other cucurbitaceous plants.

M. J. Narsimhan : Note on the presence of yeasts in some insects.

M. S. Sabhesan : Studies on the photosynthetic system of Cyperaceæ.

L. B. Kulkarni : A case of plant surgery.

G. B. Patwardhan : Some abnormal forms of phylloclades of *Opuntia elatior* Mill.

G. K. Lele : A study of the genus *Triticum* in Central India.

S. H. Prayag : Variations in the *Gossypium neglectum* types of cotton.

Sudhir Chandra Roy : Mendelian characters in linseed (*Linum usitatissimum*).

R. K. Bhide : Contabescence of the anthers in rice.

G. R. Hilson : The determination of seed weight and weight of lint per seed in *Gossypium hirsutum*.

B. Sahni : On some petrified plants from the Mesozoic and Tertiary rocks of India and Burma.

At the business meeting of the Society February 3rd, the minutes of the previous meeting were read and approved, and the Secretary-Treasurer read his report for 1921. He reported that the membership numbered 121, of whom 114 are Charter Members. There was a cash balance of Rs. 621-5-4 in the treasury on December 31, 1921.

It was decided to put Rs. 500 in a bank at fixed deposit, as a reserve fund.

The result of the correspondence ballot for two officers to be elected for 1922 was announced: Rai Bahadur K. Rangachari, M.A., L.T., of the Agricultural College, Coimbatore, was elected President,

and Prof. S. P. Agharkar, Ph.D., of Calcutta University, Vice-President. The other officers, holding over from 1921 are: Prof. Shiv Ram Kashyap, M.Sc., of the Government College, Lahore, Secretary-Treasurer, and two Councillors, Prof. Birbal Sahni, D.Sc., of Lucknow University, and the retiring President, Prof. Winfield Dudgeon. Ph.D., of Ewing Christian College, Allahabad.

Fourteen new members were added to the Society by ballot. Since the meeting, four more members have been taken in, bringing the total membership to 139.

The provisional constitution adopted at the time of formation of the Society has proved inadequate, so a committee was appointed to draw up a new constitution, to be submitted at the next meeting.

Finally, it was decided to approach the Editor of the Journal of Indian Botany with the proposal to take over the Journal as the property and official organ of the Society. The Society needs a journal, and as the Journal of Indian Botany is already well started and provides ample facility for botanical publication, it seemed wise to attempt to acquire it.

The next meeting of the Society will be held in Lucknow in connection with the Indian Science Congress, probably in January, 1923.

WINFIELD DUDGEON.

CURRENT LITERATURE

Mascre, M. Recherches sur le developpement de l'anthère chez les Solanacees (Contribution a l'etude de l'assize nourricière du pollen.) *Thèse Paris, 99 p., 101 figs. 1921.*

The author has investigated the origin, development, structure, and function of the tapetum in 20 species belonging to 14 genera of the Solanaceæ. A section is devoted to a discussion of the merits of various fixing agents and staining methods for demonstrating the different cell structures, food materials, and phases of degeneration.

The structure and behaviour of the tapetum is quite uniform throughout the plants investigated. The hypodermal archesporial cells divide by periclinal walls to form the primary sporogenous cells and an outer primary parietal layer, which in turn divides to form the outer tapetum and a layer which gives rise to the wall cells of the anther. Early during this development, the vegetative cells bordering on the inner side of the sporogenous tissue differentiates to form the inner tapetum. Despite the fact that the tapetal cells have thus a dual origin, they all have the same structure ; this is because they are all subjected to the same physiological conditions, and all have the same function of transfering food materials to the developing pollen grains. The author entirely disagrees with the view sometimes expressed that the tapetal cells are potential sporogenous cells diverted for nutritive purposes.

The life of the tapetal cells is divided into three rather well-defined periods:

1. Period of differentiation, extending from the time the cells are first set apart, to tetrad formation in the pollen mother cells. The cells divide and attain their full number and size. The protoplasm is abundant, and there is a well-developed chondriome made up of granules and short rods. The cells are always uninucleate at first, but the nuclei soon begin to divide to produce two or four daughter nuclei, which then show a decided tendency to fuse into large polyvalent nuclei.

2. Stage of maturity, during which the tapetum is actively functioning as a secreting layer. The chondriome transforms into long rods, some of which give rise to plastids in which starch grains are formed, while others give rise to granules of fatty substance. These food substances are gradually passed inward in solution to the developing pollen grains. The nuclei finally complete their fusions, and some of the large fusion nuclei may again undergo mitosis.

3. Period of degeneration. This stage begins about when the walls of the pollen grains commence to thicken. The first sign of degeneration is seen in the chondriome; then the tapetum walls become cutinised. At length the nuclei and the cytoplasm with its chondriome degenerate, and at the time of anther dehiscence only the shriveled remnants of the tapetum cells remain. Here and there cells or cell contents are found wandering out

among the pollen grains, but this seems to be nothing more than the occasional accidental dislocation or rupture of cells caused by the shriveling; it is in no sense a tapetal plasmodium.

The author also made incidental observations on the character and development of the pollen grains, and on the structure and mechanism of dehiscence of the anthers.

WINFIELD DUDGEON.

Sharp, Lester W.—Somatic chromosomes in Tradescantia. *Amer. Jour. Bot. 8 : 305-317. 2. pls. 1920.*

The details of mitosis are still very incompletely known. Exactly what happens during the reconstruction of the nuclei at telophase; the condition of the chromatin during the interphase; the method of reformation of chromosomes from the interphase reticulum; the time and method of formation of the prophase longitudinal split; and even the question of the reality of the linin framework of the chromosomes—these all are problems of modern cytology.

The author has concluded previously, following Gregoire, that at telophase the chromosomes undergo a progressive vacuolation which gradually transforms them into reticular structures, which all together constitute the chromatin network of the resting nucleus. At the next mitosis these reticulated chromosomes gradually separate from each other and condense into the prophase chromosomes. Miss Digby (on the archesporial and meiotic mitoses of Osmunda. Ann. Bot. 33: 135—170. 1919), among others, has recently produced strong evidence supporting the view that the split observed in the heterotype prophase is the reappearance of a split developed during the previous somatic telophase. The present study "was undertaken not only to test the writer's position with respect to the time of chromosome splitting in somatic mitoses, but also, by determining more precisely the nature of the transformation of the chromosomes in the somatic telophase, to ascertain to what extent, if at all, this transformation will aid in the interpretation of the heterotype prophase."

When the chromosomes begin to separate from one another during teleophase, they remain connected by thin strands of chromatic substance. At the same time minute vacuoles appear in the chromosomes, not only along the midline but also along the periphery, with no regular arrangement. It is this vacuolation of the chromosomes that has been interpreted by some other workers as a definite longitudinal split; but transverse sections of the chromosomes may show 3 or 4 vacuoles lying side by side, so that the chromosomes "can no more be called 'double' than triple or quadruple." Vacuolation continues till the outline of each chromosome is nearly or quite lost in an irregular network. This resting reticulum is regarded as made up entirely of chromatin, or perhaps more accurately, of a very fluid chromatic substance free to diffuse about through another material which composes the framework; but it cannot be interpreted as chromatin granules strung on linin threads.

The prophase of the next mitosis is largely a reversal of the process of vacuolation. The chromatin begins to condense, and the anastomoses to pull apart. As condensation proceeds, some of the vacuoles open to the exterior, leaving the chromosomes as irregular zigzag threads of uneven thickness,

but definitely *single*. These threads then straighten out into smooth threads, with few or no vacuoles remaining. It is in these single threads that the true split appears, probably larger by the formation of entirely new vacuoles. The splits become more definite, and the anastomoses between two half chromosomes give the familiar ladder-like appearance, often interpreted as "paired" or "divided chromatin granules."

The conclusion is that the longitudinal split appearing during the prophase cannot be connected with any phenomena of the preceding telophase, but occurs *de novo*. Therefore any theories, no matter how simple and attractive, which consider the paired threads of the heterotype prophase as the re-appearance of an old split in single chromosomes would be based on a false premise. The figures accompanying the paper amply bear out the author's conclusions.

WINFIELD DUDGEON.

Algae

Mitchell, Miss M. M. Research on Macrocystis. *The following is taken from the published account of a paper read before the Linnaean Soc. London, on January 19, 1922.*

Dr. E. MARION DELF gave an account of research on *Macrocystis* by Miss M. M. MICHELL and herself. After describing the distribution of the alga, the authors reviewed recent accounts of it, and showed lantern-slides in explanation.

The fertile fronds are completely submerged, smooth, dichotomously branched and usually borne on special shoots. They bear sori on both sides of the frond. Exceptional cases were described of discontinuous sori occurring in the grooves of fronds with wrinkled surface and borne on the long swimming shoots, and usually without a swim bladder at the base.

The zoospores do not appear to have been previously described. Material brought from the shore in the morning, and examined in the laboratory in the evening, showed swarming zoospores; the next morning swimming actively, and more slowly.

Cultures were made from the material in the following way:—About 2 hours after gathering, the alga was placed in a covered glass dish, with a few cover-slips at the bottom, and then sea-water was added. The piece was removed the next day, and 10 days later all the zoospores had come to rest, but showing no sign of germination. Five weeks afterwards short filaments of two different sizes were observed, comparable with the male and female gametophytes in Laminariaceæ reported by Sauvageau and Lloyd Williams. Two months later young stages of the sporophyte were visible on the cover-glasses, a thick-walled empty cell always being at the base of the sporophyte, probably the empty oogonial wall after the escape of the oospore. No sign of the antheridial cells has been noticed. The discovery of the filaments developed from the zoospores and the subsequent growth of the sporophytes from filaments brings it into line with other members of the same family.

The authors consider that the species occurring at the Cape is *Macrocystis angustifolia*, Bory, from its rhizome-like attachments.

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EDITORIAL

With this issue the Journal of Indian Botany enters on a new stage of its existence. Hitherto it has been the property, if one may use that word of a thing which only costs money, of a private individual, Mr. T. R. D. Bell, C.I.E., late Chief Conservator of Forests, Bombay, who at its inception most generously offered to guarantee its expenses during the first two critical years of its life, and followed up his promise with cheques.

Partly under the stimulus of this Journal's existence, a society of Indian Botanists was formed two years ago, under the leadership of Dr. W. Dudgeon of the Ewing Christian College, Allahabad, and when the young society felt it should have a periodical which the members might think of as their own, it was obviously more appropriate to acquire this one than to start another journal. They have therefore resolved, with the assistance of grants from most of the Indian Universities, to take over the editorial and financial responsibilities of this journal. The journal thus becomes The Official Organ, so far as a scientific journal may be called an official organ, of the Indian Botanical Society, and for this happy consummation the Society is indebted chiefly to the advocacy of its Founder, Dr. Dudgeon.

In these days when government assistance is looked for in almost every public undertaking it is a source of very considerable gratification that a private person should have been found able and willing to stand the cost of a purely scientific journal during the first two years of its course, when expenses necessarily overtop receipts. It is well known that Mr. Bell has throughout his service not confined himself to the purely official work of a Forest Officer, but possesses probably unrivalled knowlege of certain branches of forest life; and for his generous patronage of a purely botanical venture Botanists in India, and many over a wider range, will acknowledge a deep debt of gratitude.

MIXED FORMATIONS IN TIME : A NEW CONCEPT IN OECOLOGY

BY

W. T. SAXTON, M.A., F.L.S.

(*With one diagram*)

1. Introduction.

The writer has always deprecated the action of those persons who evolve new theories, from *a priori* considerations, out of their own inner consciousness, without any material evidence to support them, as well as of those who glean some facts from half a dozen published sources, diligently select those favourable to a particular pet theory, ignore all the other facts which do not fit it and rush into print.

It seems, therefore, advisable to state that the theory to be developed here has not arisen in either of these two ways. It is based mainly on some oecological work which is being carried on at the present time by the writer and some of his students. This work is likely to be continued for some months at least and meanwhile the idea gradually crystallizing from it seemed sufficiently important, in its relation to Indian oecological problems, to justify this attempt to complete the crystallizing process. It is proposed rather to explain the idea than to give details of the facts which first led to its adoption.

2. Discussion.

Probably many Indian Botanists have been struck by the extreme paucity of references to India in oecological literature. Warming's classical "Oecology of Plants" contains practically no reference to India except a few passing remarks about "Monsoon Forest" (which he quite possibly classifies incorrectly). I know of no work in recent years which has suggested any broad basis upon which detailed oecological studies in India may rest. Consequently such oecological work as has been done, apart from any question of its intrinsic merit, has no basis of correlation except European and American work. The result has been that those who have tried to define Indian plant communities have quite definitely made the attempt to fit them into the systems which have evolved in the last twenty years from the oecological work done in Western countries. Those systems are already comparatively rigid and the task of fitting our plant communities into them is not an easy one. Indeed I have come to the conclusion that it cannot be done, at least not on the lines which have been hitherto attempted.

From the oecological point of view the great difference between Europe and America on the one hand and India on the other is that the former really have no habitat which even approximately corresponds to the Indian monsoon habitat, with its succeeding eight months of drought. This is the one great factor which has been, in certain aspects, unconsciously ignored, and which *cannot* be ignored. Seasonal differences are found in other habitats, but I believe it must be admitted that they are much less profound and far reaching than those in the monsoon habitat as we see it in its typical development.

When we examine such a habitat we often find that during the year two (or it may be three) profoundly different sets of conditions are met with in the same spot. Practically these constitute two (or three) entirely *different habitats*. First a condition when both soil and air may be almost continuously water saturated for about 3 months, and when comparatively delicate mesophytic plants may flourish. If towards the end of this period the soil becomes completely water-logged, aeration soon becomes very deficient, which upsets the equilibrioum in such a way that swamp conditions arise. Whether this happens or not, and how soon, will depend, amongst other things, on the sub-soil drainage. In any case at the close of the monsoon the soil and air both gradually dry, and after about a month a period of seven months intense and absolute drought sets in. During this time the formation to be met with must be regarded as most markedly xerophytic. Only plants with some well defined xerophytic equipment can survive.

Now according to our present conceptions we think of any particular small area, if reasonably stable, as being occupied by *one* formation, though doubtless it may have different seasonal aspects and different floristic composition at different times. Still, essentially, we think of it as a *unit*.

But in such habitats as have been described above such a conception often appears absolutely untenable and absurd. Examining a hypothetical small area, such as I have mentioned, it may be supposed to be xerophytic bushland in the months of April and May, equally well to be a meadow* with scattered bushes in July and August, and possibly also to be a marsh in September and October.

The idea of "succession" is of course familiar, but this is not

* I use the term *meadow* here and elsewhere merely in an illustrative manner, without wishing to imply that there is anything in the plains of India which *exactly* corresponds to the 'meadow' of North Temperate countries, which is in fact very doubtful.

succession as understood in Oecology. Probably this will be universally admitted and it will not be necessary to discuss the point further.

From what has been said it follows that the small area in question may not be at any time (and probably in fact is not) a *pure* formation, *i.e.*, pure meadow, or pure marsh, or pure xerophytic bushland. The latter will be most nearly pure of the three, say in May, but the ground will still contain the resting organs (rhizomes, etc.) of the plants of the other two formations and possibly a very few hardy and persistent survivals of the marsh. So that in fact our area bears a mixture of three (or two if marsh does not develop) formations, the relative importance of which varies with the progression of time. This is the idea which forms the title of this essay "*Mixed formations in time.*" It is necessary to distinguish the case quite clearly from the already familiar one of a mixed formation between two pure ones, in a relatively narrow zone where they overlap. For instance woodland instead of passing over abruptly into pure grassland may first pass into an intermediate mixed zone of grassland with scattered trees. This is quite distinctly a case of *mixed formations in space.* Time does not effect the relationship in any regularly recurrent manner.

The diagram appended is meant to be no more than hypothetical, but it may serve to visualize the idea of mixed formations in time. The plain dotted line represents the relative dominance of the xerophytic formation, the—.—.—line shows the same for the mesophytic and the—...—...—line the relative dominance of helophytic vegetation. One point in the diagram may require emphasis, the vertical ordinate at any point is not meant to represent absolute dimensions, but only relative dominance.

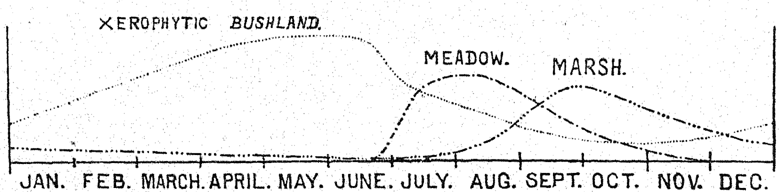


DIAGRAM TO ILLUSTRATE MIXED FORMATIONS IN TIME.

Apart from the general argument I have followed, there appear to be definite facts, derived from a study of the physiological anatomy of plants of such a mixed formation, which lend support to the theory. It is not my purpose to state or discuss them at present, especially as they are very incompletely worked out.

If I have said enough to indicate clearly what the new theory is which I am bringing forward, and in what way it promises to be of service to Indian oecology, then my task is completed for the present. I trust the statement may lead to criticism and discussion.

Summary.

Certain familiar facts are briefly described regarding climatic conditions in those parts of the world where a strong summer monsoon rain is experienced, alternating with a long and severe drought.

The theory is advanced that in such an area it often happens that we cannot regard a small and reasonably homogeneous part of it as occupied by a single unit ("formation") of vegetation, but rather that two (or even three) entirely different plant communities regularly alternate with one another, though each persists to some extent through the dominant phases of the other, thus giving rise to the idea of "Mixed formations in time."

It is suggested that Indian oecological conditions differ so widely from those of Europe and America that it is almost useless to try and fit our oecological results into their systems. India will have to evolve her own system of oecological classification.

MADHAVLAL RANCHHODLAL SCIENCE INSTITUTE,
AHMEDABAD,
11th August, 1922.

THE OECOLOGY OF SOME PLANT COMMUNITIES IN THE SAVANNAH FORMATION

BY

R. H. DASTUR, M.SC., F.L.S., AND W. T. SAXTON, M.A., F.L.S.

1. Introduction

During the last fifteen years great strides have been made in the study of Oecology. A large amount of work has been done, both in Europe and America, to increase our knowledge of plant formations and associations. In most cases, and especially where large areas have been studied including various different formations, we are of opinion that the analysis of the vegetation has not been as exact as it should be, while in other cases it has seldom been possible to decide the precise relation between the plant and the various differing factors of the habitat. For the tropics the recent papers by McLean (4) give some interesting analysis of physical factors but no detailed analysis of the vegetation is attempted.

It is of course abundantly clear that the different aspects of vegetation depend ultimately on physical factors such as water content of the soil, humidity of the air, light and temperature, but it is not always clear which of these factors is dominant in particular cases.

So far as the autbors are aware, not very much work has been done with a view to elucidating the causes, often rather obscure, which lead to somewhat marked differences of vegetation, in an area where the physical factors at first sight appear uniform, and where the differences are, in the main, rather floristic than definitely oecological; that is to say where the whole area must be held to belong to the same formation and association, although the communities * are different.

Such cases are very frequent in the vicinity of Ahmedabad † and it appeared to the writers that a more or less detailed study of one typical case might throw light on the problem as a whole. An area was selected which had been under casual observation for about 6 years. During that time nothing had been done to disturb the natural development of the vegetation and no marked changes seemed

* The term "Community" is used here to denote a unit next below that generally understood by an "Association." It thus corresponds approximately to "Variety of Association" as defined by Warming (10) or to "Society" in the sense understood by Clements (2).

† Ahmedabad is about 50 miles N.E. of the Gulf of Cambay. Lat. 23°.2′ N. Long. 72°39′ E.

to be taking place in the distribution of the species. It has always, during these years, shown a fairly sharp distinction into four parts passing from North-west to South-east and approaching the bank of the Sabarmati River. In some cases the dividing line between the communities is very abrupt but between the third and fourth parts it is more gradual.

It was apparent from the small size of the whole area, which is about half a mile from North-west to South-east, and about 100 yards from North-east to South-west, that no perceptible differences exist in the climatic factors, humidity of the air, light and temperature. The altitude was also practically constant except for a very slight depression in the second part. It seemed therefore that the area was admirably adapted to an investigation of the differences between these four parts and their causes.

A preliminary general account of the oecology of Northern Gujarat was published by Saxton and Sedgwick (7) in 1918 in which a description of the Savannah associations is given. In that paper the area we have studied is included under the heading of "other types of Savannah on Sandy Soil" (loc. cit. p. 233) and its relation to other types is shown.

2. Investigation

A. General.—The area selected is a plot of waste ground about 3 miles South-west of Ahmedabad on the North-west bank of the Sabarmati River. Its approximate dimensions have already been mentioned. For the greater part of its length it is bounded both North-east and South-west by cultivated land, but to the South-east it merges in a stripe of waste land extending along the river bank.

The four parts of the area, mentioned above, will be distinguished as Areas (I), (II), (III) and (IV), passing from North-west (I) to South-east (IV).

Area I is largely dominated by Cassia auriculata *L.*, Area II by Acacia arabica *Willd.* and Cassia auriculata *L.* in similar proportions, Areas III and IV by Saccharum Munja *Roxb.*, its dominance being more marked in Area IV.

In order to arrive at any definite conclusion five lines of research seemed to be desirable (*a*) a detailed analysis of the vegetation of the areas; (*b*) an analysis, chemical and physical, of the soils, including the water contents; (*c*) a study of the physiological anatomy of the plants concerned; (*d*) an investigation of the root systems of some of the more dominant plants and (*e*) experimental determination of the wilting point of the important plants, and their rate of transpiration

under controlled conditions. Of these five lines the last is still awaiting investigation. The present account refers to the first four, and they will now be taken up in the order named.

2-*B. Analysis of Vegetation.*—Owing to the great diversity in size of the plants on each of the four areas the ordinary method of quadrat analysis appeared to be impracticable and we did not consider it necessary to chart any permanent quadrats, since no obvious changes (as pointed out above) were taking place in these areas. A modified form of list quadrat was therefore employed which was designed to meet the special case of the diversity in size of the plants. These can be roughly graded into three sizes—(1) trees (almost absent except in area II); (2) shrubs and large erect herbs, which dominate the whole area; and (3) a carpet of low-lying creeping plants. The latter, owing to their small size, can only conveniently be studied in a quadrat less than twelve feet square, while it is necessary to employ a square of one hundred times this area to obtain an accurate figure for the trees.

To meet the difficulty we decided to employ a quadrat twelve feet square as our unit area, and to reduce all figures to correspond to this unit. For the trees a quadrat of 120 feet square was utilized, and the figures obtained, were divided by 100. For the undergrowth of small creeping plants quadrats varying from one to two feet square were used, and the figures multiplied by 144 or 36 as the case might be.

For obtaining a figure approximately representing the volume of a species we utilize the formula recommended by Clements (2) $2\, n\, H\, \Pi\, r^2$, where n represents the number of plants per unit area, H the height and r half the width. It is obvious that this formula is based upon the assumption that the plant has the form of a cylinder of height H and diameter $2\, r$, which is seldom or never the case, but on the other hand few plants depart widely from this form, and no better formula suggested itself.

As it seemed uncertain how far two quadrats in the same area could be expected to agree with one another, figures were compared in two or three cases, for the same plant in two or more quadrats located in the same area. In each case where this was done it was found that the figures obtained did not differ by more than 5 per cent. We regard $2\frac{1}{2}$ per cent. therefore as the probable error in the figures shown below:—

We have shown the actual figures for plants amounting to not less than 0·01 per cent. of the whole, and plants below this percentage are merely given in order, without actual figures.

The lists are as shown in Tables 1 to 4.

Table 1

AREA I

	Per cent.	
Cassia auriculata *Linn.* ...	44·90	Sida cordifolia *Linn.*
Ziyzphus rotundifolia *Lamk.*	12·50	Cassia Tora *Linn.*
Cenchrus biflorus *Roxb.* ...	10·96	Tribulus terrestris *Linn.*
Indigofera enneaphylla *Linn.*	8·85	Perotis latifolia *Ait.*
Saccharum Munja *Roxb.* ...	4·04	Peristrophe bicalyculata *Nees.*
Indigofera cordifolia *Heyne.*	3 84	Euphorbia pilulifera *Linn.*
Evolvulus alsinoides *Linn.*	3·27	Cyperus niveus *Retz.*
Commelina nudiflora *Linn.*	3·27	Eragrostis ciliaris *Link.* var; brachystachya *Boiss.*
Achyranthes aspera *Linn.*	2·54	Boerhaavia diffusa *Linn.*
Eleusine aegyptiaca *Desf.* ...	1·53	Justicia diffusa *Willd.*
Panicum ramosum *Linn.* ...	1·34	Cenchrus catharticus *Delile.*
Spermacoce hispida *Linn.* ...	1·15	Eragrostis tremula *Hochst.*
Sida grewioides *Guill.* ...	·96	Convolvulus pluricaulis *Choisy.*
Pavonia zeylanica *Cav.* ...	·38	Leptadenia reticulata *W. & A.*
Cassia obtusa *Roxb.* ...	·19	
Crotalaria medicaginea *Lamk.*	·19	

Table 2

AREA II

	Per cent.		Per cent.
Cassia auriculata *Linn.* ...	48·71	Oldenlandia corymbosa *Linn.*	·12
Acacia arabica *Willd.* ...	42·71	Heliotropium marifolium *Retz.*	·08
Evolvulus alsinoides *Linn.*	1·8	Euphorbia pilulifera *Linn.*	·08
Saccharum Munja *Roxb.* ...	1·37	Eleusine aegyptiaca *Desf.* ...	·08
Eragrostis tenella *Roem. & Schult.* var; plumosa Stapf.	1·2	Euphorbia microphylla *Heyne.*	·04
Crotalaria medicaginea *Lamk.*	1·15	Indigofera cordifolia *Heyne.*	·03
Calotropis procera *R. Br.* ...	·87	Striga euphrasioides *Benth.*	·02
Cenchrus biflorus *Roxb.* ...	·68	Vandellia crustacea *Benth.*	·02
Sida cordifolia *Linn.* ...	·53	Chloris virgata *Sw.* ...	·02
Eragrostis ciliaris *Link.* var; brachystachya *Boiss.* ...	·26	Bonnaya brachiata *Link. & Otto.*	
		Digitaria royleana *Prain.*	
		Leptadenia reticulata *W. & A.*	

Table 3

AREA III

	Per cent.		Per cent.
Saccharum Munja *Roxb.* ...	91·16	Indigofera linifolia *Retz.* ...	·087
Calotropis procera *R. Br.* ...	3·68	Spermacoce hispida *Linn.*	
Cassia auriculata *Linn.* ...	3·67	Peristrophe bicalyculata *Nees.*	
Sida cordifolia *Linn.* ...	3·49	Perotis latifolia *Ait.*	
Alysicarpus vaginalis *Dc.* ...	3·48	Eragrostis ciliaris *Link.* var; brachystachya *Boiss.*	
Indigofera enneaphylla *Linn.*	·262	Boerhaavia diffusa *Linn.*	
Phaseolus trilobus *Ait.* ...	·262	Cenchrus catharticus *Delile.*	
Indigofera cordifolia *Heyne.*	·087	Eragrostis tremula *Hochst.*	
Tephrosia tenuis *Wall.* ...	·087		

Table 4

AREA IV

	Per cent.	
Saccharum Munja *Roxb.* ...	96·6	Eleusine aegyptiaca *Desf.*
Indigofera linifolia *Retz.* ...	1·36	Eragrastis ciliaris *Link.* var ; brachystachya *Boiss.*
Indigofera cordifolia *Heyne.*	·68	Perotis latifolia *Ait.*
Phaseolus trilobus *Ait.* ...	·34	Panicum ramosum *Linn.*
Crotalaria Burhia *Ham.* ...	·34	Cyperus niveus *Retz.*
Indigofera enneaphylla *Linn.*	·34	Eragrostis tremula *Hochst.*
Calotropis procera *R. Br.* ...	·34	Cenchrus catharticus *Delile.*

2·*C. Soil Analysis.*—The soil throughout the four areas is an almost pure sand, but in Area II there is a perceptible proportion of humus. Treatment of the soils with dilute acid indicated the presence of carbonates. No complete analysis was attempted, but magnesium carbonate seemed to be present in greater quantity than the calcium salt.

By treatment of weighed samples with measured volumes of standard acid, and titrating the remaining acid with standard alkali, carbonates were estimated as CO_2. Again by calcining weighed samples, allowing them to cool in an atmosphere free from CO_2, and weighing again, it was assumed that the loss of weight would represent CO_2 plus humus. By subtracting from these figures those obtained previously for CO_2 alone, the amount of humus was estimated. The figures were as follows:—

Table 5

Area	Humus plus CO_2 Per cent.	CO_2 Per cent.	Humus (by difference) Per cent.
I	2·12	0·77	1·35
II	4·37	1·50	2·87
III	2·48	1·38	1·10
IV	3·38	2·56	0·83

The general aspect of the vegetation, and the prevalence of families usually regarded as halophytic, suggested that sodium chloride might be present to an appreciable extent, but repeated tests of filtered soil extracts with dilute silver nitrate, gave negative results in each case.

From these results it did not appear, with the possible exception of area II, that the differences in the vegetation could be caused by differences in the chemical nature of the soil.

Attention was next directed to the water content of the soil. In all our earlier estimates samples were taken to a depth of 8 inches only. On May 13th samples were also taken from each area at a depth of 18 inches, but the results were identical in each case with those taken at 8 inches. From the study of root systems to be described below, it afterwards appeared that it might have been better to study the water content at much greater depths, and we hope to complete a study of this question at a later date. Nevertheless the study of water content to a depth of 8 inches only, yielded results of considerable interest, and we think that the figures obtained are likely to bear a close relation to the water content at lower levels, especially in view of the identical results obtained at a depth of 18 inches. The samples were usually taken in air-tight, screw-top aluminium jars and the water content calculated, after drying at 100 C., as percentages of the wet soil.

On some occasions the soil temperatures were recorded at the same time, but no appreciable differences were found in any of the areas and these records were therefore discontinued. The records of water content are as follows:—

Table 6

No.	Date	Area I Per cent.	Area II Per cent.	Area III Per cent.	Area IV Per cent.	Remarks
1.	28-6-1919	5·30	...	3·50	...	Rainfall 0·56 over night.
2.	18-8-1919	4·15	8·60	3·01	1·78	Rainfall 0·01 over night.
3.	9-9-1919	2·26	4·51	1·88	1·42	No rain for 15 days.
4.	30-3-1920	0·67	2·23	0·58	0·35	Temp. 106·6 F.
5.	10-5-1920	0·67	1·80	0·57	0·35	Temp. 109·8 F.
6.	13-5-1920	0·66	1·60	0·53	0·34	Temp. 107·9 F.

As rain fell on 13-5-1920, after No. 6, the records were discontinued.

An examination of these figures indicates (1) that the ratio of water content in the four areas remains similar at all seasons, the order being always II, I, III, IV, and (2) that in the hot weather the actual water content in each case appears to converge to a minimum, with the possible exception of area II. The next step was to endeavour to connect the water content with the physical structure of the soil, and this proved a more difficult problem than was anticipated. In the first place the soils were separated into three grades of fineness by passing air-dry weighed samples of each through sieves of 30 and 60 meshes to the inch. As in each case the proportion of small stones, etc., too large to pass through the 30 mesh sieve was very

small and appeared unlikely to have any possible effect on the water content this portion was neglected.

The size of the holes in the sieves varies with the thickness of the wire, so camera lucida drawings of a few meshes were made in each case under the microscope and carefully measured by comparison with drawings of a standard stage micrometer. In this way the average diameter of the holes was accurately measured, and this was found to eliminate some discrepancies noticed between results obtained with different sets of sieves. In the following tables, therefore, we show only the average diameter of the holes and neglect references to the number of meshes to the linear inch.

Table 7

	Area I Per cent.	Area II Per cent.	Area III Per cent.	Area IV Per cent.
Particles of diameters less than ·510 m.m. and more than ·227 m.m.	25·13	8·40	15·70	18·30
Particles of less than ·227 m.m. diameter.	72·54	90·33	84·04	81·30

N.B.—The differences of the totals from 100 represents stones, etc.

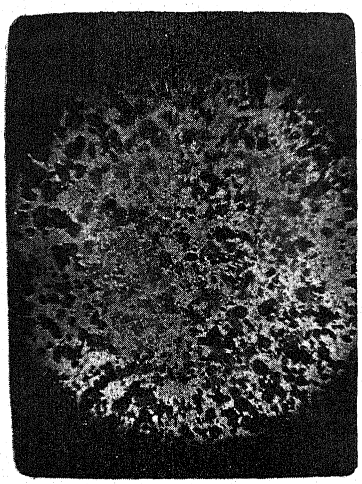
As so large a proportion passed through the sieve of smaller mesh another set of three sieves was employed of 30, 60 and 90 meshes to the inch, with the following results :—

Table 8

	Area I Per cent.	Area II Per cent.	Area III Per cent.	Area IV Per cent.
Less than ·571 m.m. more than ·262 m.m.	17·27	5·10	3·21	10·07
Less than ·262 m.m. more than ·200 m.m.	35·99	3·70	23·16	50·00
Less than ·200 m.m.	46·74	91·20	73·62	39·93

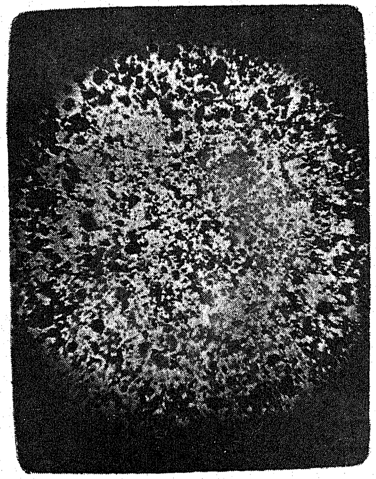
It was obvious that the water content could not be explained in terms of these figures since the proportion of smallest particle in table 7 was in the order II, III, IV, I, and that of table 8 in the order II, III, I, IV, while the order of the water content was II, I III, IV. It seemed likely therefore that the water content must depend on the proportion of particles of a decidedly smaller size than those passing through a sieve of 90 meshes. No finer sieve being obtainable, and as it appeared doubtful whether it could be made sufficiently accurate in any case, some other means had to be devised to solve the problem.

FIG. 1



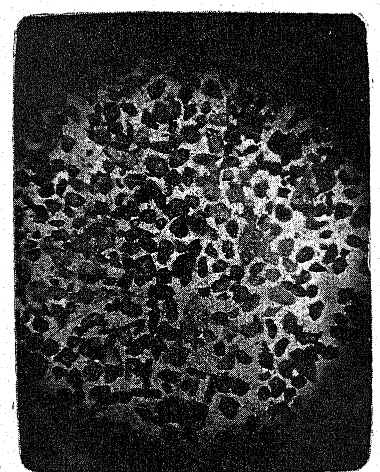
Area 1

FIG. 2



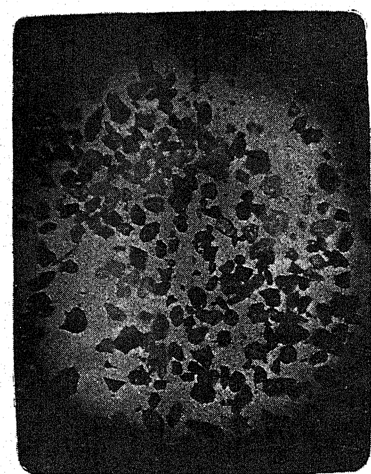
Area 2

FIG. 3



Area 3

FIG. 4



Area 4

Microphotographs of the soil particles passing through 8100 meshes per square inch. (Diameter of each mesh = ·2 mm.) × 20.

After thorough mixing of a soil sample from each area which had passed through the finest sieve a small amount was spread on a glass slide and a microphotograph taken of it.

These photos are reproduced here as figures 1 to 4 and at once show striking differences, but we wished to get a quantitative estimate and so adopted the following method. The magnification of the photo is 20 diameters and by measuring photographs of particular particles of diameter $0{\cdot}15 \times 20$ m.m.; $0{\cdot}10 \times 20$ m.m.; $0{\cdot}05 \times 20$ m.m. and $0{\cdot}01 \times 20$ m.m. we were able to form an estimate of how many particles of the following ranges of size were present in a unit area :—0·20—0·15 m.m.; 0·15—0·10 m.m.; 0·10—0·05 m.m.; 0·05—0·01 m.m.; and less than 0·01 (estimated as 0·01—0·001).

The estimate was made by means of a wire ring of one square c.m. area which was placed in various positions on the photograph and counts of the particles of the five sizes made in each position. The average of several counts was taken as the number of particles present in the unit area. It was then assumed (1) that the average size of particles in each class was the arithmetic mean between the largest and the smallest; (2) that the specific gravity of large and small particles was approximately constant;* and (3) that each particle may be regarded as a sphere. From these three assumptions the relative weights of the particles were calculated from the formula $\frac{4}{3}\pi r^3 n$ where n = the number of particles in unit area and r = half the average diameter of the particles. Now in a sample of any one area if X_1, X_2, X_3, X_4, X_5 are the weights calculated as above then $\sum X = X_1 + X_2 + X_3 + X_4 + X_5$, and if Y = per cent. of particles less than 0·2 m.m. diameter for that area (*vide* Table 8) then :—

$$\frac{X_1 \times Y}{100 \times \sum X} = \text{per cent. weight of particles } 0{\cdot}2\text{—}0{\cdot}15 \text{ m.m.}$$

$$\frac{X_2 \times Y}{100 \times \sum X} = \text{per cent. weight of particles } 0{\cdot}15\text{—}0{\cdot}10 \text{ m.m.}$$

....

$$\frac{X_5 \times Y}{100 \times \sum X} = \text{per cent. weight of particles less than } 0{\cdot}01 \text{ m.m.}$$

The results of this calculation for each area are incorporated together with the figures from Table 8 in Table 9 below. The weight of particles less than 0·01 m.m. diameter was found to be negligible and has been omitted.

* There is likely to be a source of error in assumption (2), since the larger particles are likely to be mainly sand, and the smaller mainly humus. We were not able to find a means of avoiding this error.

Table 9

Diameter of particles	Area I per cent. weight	Area II per cent. weight	Area III per cent. weight	Area IV per cent. weight
0·57—0·26 m.m.	17·27	5·10	3·21	10·07
0·26—0·20 m.m.	35·99	3·70	23·16	50·00
0·20—0·15 m.m.	2[illegible]·70	*Nil*	63·10	30·33
0·15—0·10 m.m.	15·30	19·92	11·53	8·65
0·10—0·05 m.m.	9·80	64·36	2·47	0·21
0·05—0·01 m.m.	0·87	6·90	0·08	0·01

From this table the interesting result is obtained that each of the last three columns agrees with the expectation derived from the water content determination of the soil and in this particular series of soils the water content would appear to depend almost entirely on the percentage weight of soil particles lying between 0·15 and 0·05 m.m. in diameter.

2-*D. Physiological Anatomy.*—Side by side with the investigations already recorded the anatomy of some of the more typical plants was also studied. In most cases both leaves and roots were examined but in the descriptions following the root is only mentioned where it shows some point of interest. Leaf anatomy is described in each case except in Cassia auriculata where no features of special interest were noted.

Up to the present we have only been able to show very slight correlation of the anatomical features with the distribution within the area studied. It is possible that further research may throw light on this point, but we are doubtful if this is to be expected.

There is of course no doubt whatever that plants are often anatomically very well adapted to extreme conditions of any kind, but there is also little doubt that plants often show unexpected resistance to unfavourable conditions when they are apparently very poorly adapted to that end, and our opinion is that such resistance must in many cases depend on some obscure factor which has not as yet come to light, but which is independent of the anatomy.

We give below a brief description of the anatomy of each plant investigated, pointing out the xerophytic characters in each case.

Cassia auriculata *Linn.*

This is a perennial shrub about three to four feet high, flowering more or less all the year round. The oblong leaflets are about $\frac{1}{2}'' \times \frac{1}{3}''$. With the exception of a few scattered hairs on both surfaces no apparent xerophytic adaptations are met with in the leaves.

The plant has a very long tap-root. The actual length in a full grown plant has not yet been investigated but the root of quite a

young plant, probably a year old, was found to reach a depth of about five feet.

The older parts of the root (Fig. 5) are bounded by a well-developed layer of cork within which is a thick band of phloem and pericycle, the exact limits of which are not clearly defined. The medullary rays are conspicuous in the phloem and pass outwards into groups of large cells which we regard as water storage tissue. Groups of sclerenchymatous cells are also found. It seems to have been assumed that such structures afford protection against evaporation, but it is not clear that any evidence exists to support this view, and it is more probable that they serve as a protection against crushing when the soil contracts or expands as the result of changes in the water content.

A large amount of tannin is found in all parts of the plant. It is probable that this is of value to the plant in some way not at present understood.

The green and healthy appearance of the plant in the dryest weather is often remarkable.

Lepidogathis trinervis *Nees.*

This is a perennial herb with a very long tap-root. There is practically no main stem, branches being formed at the ground level which are prostrate or nearly so. The leaves are small and linear lanceolate and show scabrid hairs on the lower surface. Xerophytic characters in the leaf (Fig. 6) are by no means marked. Cuticle is noticeable on the outer walls of the epidermis, and the cells of the bundle sheath are possibly water storing. These cells are quite colourless and have little visible contents. The cystoliths, frequently met with in Acanthaceae, are an interesting feature. One is seen in longitudinal section on the upper side of the section figured, and one above and one below are seen in transverse section. The sessile glands are also noticeable. The stomata (Fig. 6.*a.*) have no special xerophytic feature.

This plant persists in a healthy condition throughout the whole hot weather. No features of special interest are found in the root.

Calotropis procera *R. Br.*

This is a common large shrub containing large quantities of milky latex. It has a long tap-root and bears large, somewhat succulent, oval leaves.

Very young leaves close to the growing point are found to be covered with a white layer of wax, mixed with hairs, forming a

protective covering against transpiration. If this layer is removed carefully it is found that the white wax is again excreted but without any hairs. As the leaves grow older the wax gradually disappears, a very small amount only remaining on the lower surface of old leaves.

The thickness of the leaves (Fig. 7) is considerable. Three or four distinct layers of palisade are found and a large amount of spongy parenchyma with plentiful intercellular spaces. No specialized water storing tissue is found, but it can hardly be doubted that this function is carried out by most, if not all, of the assimilating tissue of the leaf. The stomata (Fig. 7.*a.*) are small and sunken.

The normal exposure of the leaves is horizontal, but under severe xerophytic conditions they take up a vertical position.

Saccharum Munja *Roxb.*

This is almost the only plant persisting through the dry season in which a tap-root is not found. On the other hand the leaves are decidedly more xerophytic than those of the plants already considered.

This is a tall grass, reaching a height of 6 to 8 feet and growing from a fairly deeply placed rhizome. The leaves are vertically placed and are of about this length and each consists of a very stout midrib carrying an adaxially directed wing at either side. The margin of each wing is very finely serrulate and often draws blood with a single touch of its razor like edge.

A transverse section is shown in Fig. 8-*a*, a small part of the wing being shown on a larger scale in Fig. 8-*b*, a single stoma in section in Fig. 8-*c*., and a stoma from upper and lower surfaces in Figs. 8-*d*. and 8-*e*.

We regard the tissue of the midrib as water storing and the groups of large cells on the adaxial surface of the lamina probably sub-serve the double function of water storage and motor cells. But while the leaf margins roll inwards in dry weather it is a somewhat remarkable fact that the stomata are slightly more numerous and equally well developed (cf. Figs. 8*d*. and 8*e*.) on the outer (abaxial) surface. The scarcity of intercellular spaces, the well developed cuticle and the considerable amount of sclerenchyma may all be regarded as xerophilous characters.

In other respects the anatomy is more or less that of a typical grass.

Evolvulus alsinoides *Linn.*

This plant is of a similar oecolcgical type to Lepidogathis. It possesses a tap-root about 4 feet in length and prostrate branches radiate in various directions from about the ground level. Its small

blue flowers may be found at all times of the year but it does not remain so vigorous as Cassia and Lepidogathis under unfavourable conditions.

The small lanceolate leaves are completely covered on both surfaces with long appressed hairs, all directed towards the apex. They are rather thin (Fig. 9) and the assimilating tissue is composed almost entirely of short palisade cells. The stomata (Fig. 9.*a*) are not sunk and only a small number of water storing cells are seen, neither is there any strong development of cuticle.

Cassia obtusa *Roxb.*

This small shrub is by no means so pronounced a xerophyte as C. auriculata, and consequently few plants survive the hot weather. We have only noted it in areas I and II. It possesses the usual long tap-root. The structure of the leaf has been recently described by Sabnis (6). His statement that the leaf is isobilateral is not quite applicable to our specimens, as there is a marked difference between the pallisade tissue on the adaxial and abaxial sides. We also fail to find hairs on the lower epidermis, though a very few short appressed unicellular hairs have been noted on the upper epidermis. In other respects our sections agree with his description. The cuticle is fairly well developed but no other marked xerophytic characters are met with.

Boerhaavia diffusa *Linn.*

This is of the same general type as Lepidogathis and Evolvulus, with a long tap root and spreading prostrate (or nearly) branches. There is only a small amount of central vascular tissue in the tap-root, and outside this is a wide belt of parenchyma, densely packed with starch, and containing a considerable quantity of raphides. In this belt many small vascular strands are seen, such as are characteristic of the family Nyctagineae, as described by Solereder (8). The root is bounded by a broad band of cork.

The leaf (Fig. 10) shows a thick cuticle on both surfaces and some of the epidermal cells are full of tannin. A feature of the anatomy is that the palisade is of the girdle type. The water storing cells of the bundle sheath also contain tannin. A few multicellular hairs are found on both surfaces, and the small stomata of the upper epidermis are slightly sunken and have cuticular ridges both above and below, as shown in figure 10*a*. The leaves of Boerhaavia are

deciduous under adverse conditions, so that the plant may become very inconspicuous during the dry weather.

Counts were made of the stomata in the upper and lower surfaces of leaves of Lepidogathis trinervis, Calotropis procera, Evolvulus alsinoides and Boerhaavia diffusa, with the following results, the numbers being calculated for one square millimetre of surface:—

—	UPPER EPIDERMIS	LOWER EPIDERMIS
Boerhaavia	66 — 73	66 — 80
Lepidogathis	$\pm$ 90	$\pm$ 180
Evolvulus	$\pm$ 100	140 — 200
Calotropis	300 — 375	360 — 470

It is somewhat remarkable that each plant has a considerable number of stomata on the upper surface of the leaf.

We have noted above the prevalence of tannin in some of the plants we have studied. Tannin is apparently of very common occurrence in some types of xerophytic plants, as for instance in many of the phyllode-bearing Acacias (Wattles), and Haas and Hill (3) quote Warming as suggesting that the tannin in some way retards evaporation of water. Since tannins are usually regarded as colloids it appeared theoretically unlikely that this could have any effect on the vapour pressure (and hence on the rate of evaporation) of water. But as the tannin-bearing Cassia auriculata seemed to remain fresher and more vigorous than any other plant of our area during the hot weather we tried to test the question. Two weighed watch glasses each containing three grams of distilled water were taken, and to one was added ·05 grams of tannic acid. After standing side by side for three hours they were weighed again and the loss of weight was found to be identical. This very simple experiment cannot be regarded as proof that tannin does not in any way check evaporation in the plant, but we certainly feel that any statement implying that tannin has such a function would need to be supported by very definite evidence, which has not, we believe, been forthcoming up to the present.

2-*E. Root Systems.*—The importance of the root system in oecological work was emphasized by Cannon **(1)** in his work on the root systems of desert plants, and this work was extended by Markle **(5)**, while some elaborate investigations on root systems in various formations have been recently carried out by Weaver **(11)**.

Cannon distinguishes three types of root systems :—(1) A generalized type with tap-root and branches both well developed, (2) A specialized type with a long unbranched tap-root, and (3) A type in which laterals develop much more strongly than the tap-root. Our investigations of the root systems of some of the more typical plants of these communities showed a very marked tendency to the development of the second type defined by Cannon (**1**), namely a straight unbranched tap-root extending to a very considerable depth, varying from about four feet in the case of quite small plants of Boerhaavia or Lepidogathis, up to about sixteen feet, or possibly more, in the case of old plants of Crotalaria Burhia. Exceptions to this were found chiefly among the grasses. Thus Saccharum has a short freely branched thick rhizome, on which large numbers of unbranched adventitious roots about a foot in length are produced. These extend downwards only about two feet under the soil (the rhizome being about one foot deep).

Few of the shallow rooted grasses persist through the hot season, so far as can be seen, but it is not unlikely that underground parts (rhizome, etc.) may survive. Observations on this question are incomplete at present and it is hoped to obtain definite information later. Of other shallow-rooted plants Spermacoce. Euphorbia microphylla and E. pilulifera, Striga, Vandellia, Oldenlandia, Bonnaya, Heliotropium, and Commelina, and possibly one or two others, appear to be annuals and do not survive the dry season. Several of these occur only in area II *e.g.* Oldenlandia, Vandellia and Bonnaya. The following plants are known to conform to the common type with a long tap-root: Crotalaria Burhia, Convolvulus, Tribulus, Achyranthes, Evolvulus, Indigofera enneaphylla, I. cordifolia, I. linifolia, Cassia auriculata, Lepidogathis, Calotropis, Cassia obtusa and Leptadenia reticulata. Probably some plants may be added later to this list, which includes a large majority of the plants which visibly persist through the whole hot weather. The root systems, therefore, seem of a very similar type to those recently described by Hamshaw Thomas (**9**) for the plants of the Libyan Desert.

3. Discussion

The climate of Ahmedabad normally has three well marked phases in the year. (1) June to end of September; moderate humidity and frequent rainfall, averaging about 30 inches for the period, the outside limits seldom exceeding 40 inches maximum and 15 inches minimum; day temperatures about 90° F. (2) October to end of

February; low humidity and complete absence of rain; temperature high in October (about 100° F), and moderate for the remaining months (about 75° F). (3) March to the middle of June; low humidity and a complete absence of rain and very high temperatures, average shade maximum about 105° F. or over.

It is seen therefore that perennial plants must be capable of surviving at least eight months during which either no rain falls or the amount is negligible.

No plant can survive such an ordeal unless it possesses some xerophytic adaptations. In sections 2-*D.* and 2-*E.* it has been shown that all the plants that survive the period of drought show at least one such adaptation to xerophytic conditions and usually more than one. Of the various adaptations found there is no doubt that the long unbranched tap-root is the most important.

Of pronounced xerophytes which do not possess this character Saccharum Munja is the most important, and leaf form and structure in this plant shows far greater xerophytic adaptation than in any of the tap-rooted plants. In the present state of knowledge it is not possible to estimate the relative advantage to the plant of a long tap-root as constrasted with xerophytic adaptations of the leaves, but as such a plant as Cassia auriculata survives the most prolonged drought with numerous leaves in which little or no xerophytic adaptation can be detected either in form or structure, it is clear that the long tap-root must be a factor of importance.

As the water content of the soil at varying depths during the dry weather still remains to be investigated it is not at present possible to correlate the length of the root system with available water supply. The recent researches of Weaver (**11**) have shown that the depth of penetration of roots in various formations is much greater than was previously realized, and owing to the extreme difficulty of excavating the fine root endings it is probable that our own estimates are somewhat less than they should be.

Our investigation has proved that the differences in vegetation over a restricted area, such as that described, are produced entirely by edaphic factors.

We have been able to show that the water content in the areas we have studied was controlled by the percentage of soil particles of less than ·15 m.m. diameter and that consistent results cannot be looked for by separating particles below any greater maximum diameter than this.

We have developed a method of calculating the percentage weights of particles of various sizes which has been briefly explained in section

2-*C*. and which appeared to yield consistent results. We have also developed a list quadrat method for the analysis of vegetation which includes plants of very diverse size, and this seems to give satisfactory results so far as we have checked it. We have at present found it impossible to detect any constant differences in physiological anatomy between the plants of the four areas, but it is noticeable that a larger proportion of shallow rooted annuals is met with in area II than in the other three while the grasses also differ a good deal from those found elsewhere.

As between areas I, III and IV the order of frequency of the Indigoferas is interesting. In area I and III it is I. enneaphylla, I. cordifolia, I. linifolia (area III only), in area IV it is I. linifolia, I. cordifolia, I. enneaphylla. The order of the three grasses, Panicum ramosum, Perotis latifolia and Eragrostis ciliaris var. brachystachya, is also of interest. They occur in the order named in area I. The second and third occur in area III in the same order, while the order of all three is reversed in area IV.

An alternative view to the one put forward by us is possible to account for the differences in vegetation of the four areas. Areas I, II, III, IV are believed to have been exposed in turn by the movement of the river Sabarmati away from its N.-W. bank and towards the S.-E. bank. It might be suggested that the distribution of the plants is merely due to the successive invasion of the areas I to IV from the N.-W. and that the present occupants represent four stages in the process. But if this were so we should find (*a*) a continuous change in the character of areas I to III tending towards that of area IV, and (*b*) the dividing line between successive areas would be less abrupt. As regards (*a*) no such continuous change appears to be going on, so far as can be judged from observations extending over six years, and in regard to (*b*) it has already been mentioned that the change in vegetation, except between III and IV is remarkably abrupt. This theory therefore appears untenable. The effect of flooding is, however, clearly traceable in area II where the slightly lower level has brought about the deposition of silt, resulting in a higher proportion of humus than in the other areas, and hence in a higher water content.

Description of Figures in Plate I

Figure 5. Transverse section of the root of Cassia auriculata *Linn.* × 200. Note the fan-like arrangement of large water-storing (?) cells opposite the two medullary rays and the groups of sclerenchyma. A good deal of starch is present, but has not been shown in the drawing.

Figure 6. Transverse section of the leaf lamina of Lepidogathis trinervis *Nees.* × 144. Note three cystoliths and three glands.

Figure 6. *a.* Stoma of the same, from the upper epidermis. × 800.

Figure 7. Transverse section of the leaf lamina of Calotropis procera *R. Br.* × 144. A part of a latex tube is shown.

Figure 7. *a.* Stoma of the same, from the upper epidermis. × 540.

Figure 8. *a.* Transverse section of the leaf of Saccharum Munja *Roxb.* × 13.

Figure 8. *b.* Part of the same. × 260. Note the large motor and water storing cells of the upper surface.

Figure 8. *c.* Stoma of the same, from the lower epidermis. × 800.

Figure 8. *d.* Surface view of stoma; upper epidermis. × 800.

Figure 8. *e.* Surface view of stoma; lower epidermis. × 800.

Figure 9. Transverse section of the leaf lamina of Evolvulus alsinoides *Linn.* × 230. Note the large piliferous cell in the lower epidermis. Such cells are scattered over the lower surface, and from each two long, unicellular hairs arise, the base of one being shown in the figure.

Figure 9. *a.* Stoma of the same, from the upper epidermis. × 540.

Figure 10. Transverse section of the leaf lamina of Boerhaavia diffusa *Linn.* ×144. Note the girdle arrangement of palisade, the cells of which converge towards the bundle-sheath; also the multicellular hairs.

Figure 10. *a.* Stoma of the same, from the upper epidermis. × 540. Note the conspicuous cuticular ridges above and the less marked ones below.

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This investigation has been carried out in the Botanical Laboratory of the Madhavlal Ranchhodlal Science Institute, Ahmedabad.

SOME OBSERVATIONS ON THE ANCHORING PADS OF GYMNOPETALUM COCHINCHINENSE *Kurz* AND SOME OTHER CUCURBITACEOUS PLANTS

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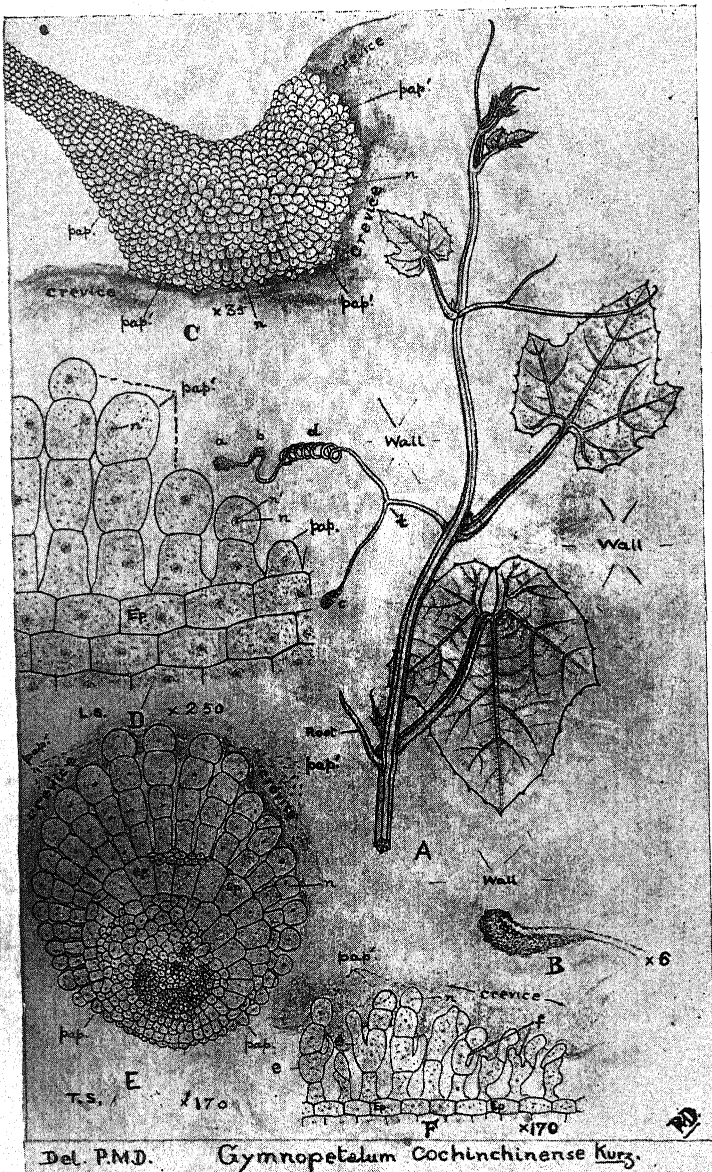
It is a matter of common knowledge that, among 'tendril-climbers', there are some plants, in which portions of tendrils are modified into 'anchoring pads' more commonly known as 'adhesive discs'. In ordinary text-books we often find *Ampelopsis quinquefolia* Michx. (= *Vitis hederacea* Ehrh.), a native of N. America, and *A. Veitchii* Hort. (= *Vitis inconstans* Miq.), a native of Japan, commonly quoted as examples of such disc-bearing plants. But, it should by no means be concluded therefrom that, such 'pads' or 'discs' are restricted to the tendrils of some species of Vitis (N. O. Ampelideae) only. As a matter of fact, such 'pads' or 'discs' have been noticed in some plants belonging to different natural orders *e.g.* Cucurbitaceae and Bignoniaceae as well. Darwin, in his very interesting book.—'The Movements and Habits of Climbing Plants,' has dealt in a masterly way with some of these plants.

In the present paper it is, therefore, proposed to confine the author's observations principally to the anchoring pads met with in the tendrils of *Gymnopetalum cochinchinense* Kurz and incidentally to a few other plants belonging to the natural order Cucurbitaceae. These observations are likely to prove interesting in view of the fact that, the majority of the plants mentioned here, being confined chiefly to the tropics, do not seem to have been studied by the previous workers *viz*: Darwin, Uhlworm, Goebel, Haberlandt, Yasuda and others. The author has, for reasons mentioned below, preferred to call these structures here as 'anchoring pads' instead of 'adhesive discs.' The term 'disc' seem to connote the idea of a flat circular surface as we find in the tendrils of *Ampelopsis quinquefolia* Michx. = *Vitis hederacea* Ehrh.) and *V. assamica* Laws.

The mature tendrils of *Gymnopetalum Cochinchinense* are usually branched (see fig. A) and it is on the apical and sub-apical regions of these arms that the anchoring pads are found to develop.



Del. P.M.D. Gymnopetalum Cochinchinense Kurz.

Under normal conditions, when a tendril of this plant meets with a suitable support, it behaves like other ordinary tendrils and in course of a few days it coils round the latter. As a result of stimulation due to contact, hypertrophy usually sets out in the epidermal cells on the side of contact, and these become enlarged and thickened and the grip thus becomes firmer. No pad has been found to develop under such circumstances.

But if a tendril happens to come in contact with a large flat and rough surface (*e.g.* a sand-plastered wall), which is unsuitable for it to coil round, then, at first, the tips of its arms begin to crawl like root-tips into the minute crevices, and, later on, as a result of the repeated but temporary applications of contact-stimulus and of the mechanical retardation on the cells involved on the side of contact, certain secondary stimulatory effects are induced in the regions of contact. The cells in the regions of repeated contact (*e.g*, a, b, & c in fig. A) gradually begin to swell, showing that a certain amount of acceleration of growth has set out in the cells involved in those regions. Such whitish swellings are by no means confined to the convex side of the apices of tendrils, but have been noticed occasionally in the convexly-curved sub-apical regions of contact (*e.g.* b in fig. A.) too. In course of a few days, the stimulated epidermal cells in and around the convexly-curved regions of contact (a, b & c in fig. A.), begin to develop into very thin-walled little white knob-like unicellular papillae (pap. in figs. B & C.). In a few more days, with the progress of the cell-division and the development of the transverse cell-walls, these papillae grow out into white hypertrophied 2-4-or even 5-celled linear-oblong or clavate trichomes (pap. in figs. C.-E.). Each of these trichomes is seated on a cushion of bulbously-swollen epidermal cell. The tips of the arms of tendrils, at this stage, being studded with the papillae and trichomes on the side of contact, assume, more or less the shape of a club-shaped round brush with bristles on it on one side (figs. B & C.).

These trichomes, by entering into the nooks and crevices (see figs. C. E. & F.) with which they come in contact, fit themselves nicely to the unevenness of the surface of the uncongenial support. This contact is usually brought about more closely by the additional adhesion, to the uneven surface of the support, of the branches (see fig. F.) of some of the cells of the multicellular trichomes. The trichomes thus pave the way of bringing the pads into very intimate contact with the surface of the support. This contact becomes ultimately so intimate that, in one instance, the writer has seen a single tiny pad supporting the weight of all the branches with leaves

which would amount to not less than 150 grains (Apoth.). In such a case, wind or any other shaking-influence cannot easily dislodge the firmly attached pads from the crevices and any violent attempt to separate a tendril from its support usually ends in a part of the tendril-filament being detached, instead of the entire pad being completely detached. It should also be stated here that such regions of contact are usually fringed (see Figs. C-E) with multicellular trichomes ending in unicellular papillae, as we pass our eyes from the areas of contact to the margins. The free portion of a tendril-branch lying between an adherent pad and the axil does not, however, remain inactive, but, usually twists itself (see d in Fig. A) into a spiral coil and thus assists the plant in gradually scrambling over the uncongenial support. This probably illustrates a case of "Co-adaptation" coming into play. The pads in *Gymnopetalum cochinchinense* do not seem to appear in the absence of any contact stimulus and they have not been observed to become woody ultimately.

It will not perhaps be out of place to mention here that, shade and moisture seem to favour, while strong light and drought seem to retard, the development of these anchoring organs. The pads are negatively heliotropic.

The author has noticed that, in carefully detached pads, the thin-walled papillae and the cells of the trichomes are quite turgid and intact. The nuclei (n) are very clearly seen as tiny black specks in the cells in Fig. C, and the nucleoli (n') in the nuclei in the highly magnified Fig. D. Silica particles, adhering to the outer walls of the cells of the papillae and trichomes, appear as highly refractive dots under a powerful microscope.

Some of the papillae and trichomes (see fig. F) described above seem to resemble some of those noticed by Uhlworm on the surfaces of the calyx, petioles and internodes of *Cucurbita Pepo* L. and figured (see figs. 40, 43, 46–49) in Bot. Zeitung (1873) taf. X. The trichomes described above do not, however, agree with any of the 4 kinds of trichomes described and figured by Yasuda in Journ. Coll. Sc. Imp. Acad. Univ. Tokyo. XVIII (1903).

In dealing with the 'Adhesive disks of tendrils' Haberlandt (**6.** p. 208) says of those of Ampelopsis (= Vitis)—"The first result of contact stimulation is the abundant serection of a mucilaginous substance, which owes its origin (in part at any rate) to the gelatinisation of the entire outer epidermal wall, with the exception of the cuticle and the innermost pellicle. According to Lengerken, mucilage is also secreted within the cell-cavity whence it passes to the outside. What-

ever its origin, the mucilage ultimately exudes, after rupturing the cuticle, and glues the disc to the substratum". A similar view is shared by several other renowned authors, *e.g.* Darwin (**3**. pp. 102, 135 and 147), Vines (**21**. p. 411), Kerner and Oliver (**8**. p. 699), Goebel (**4**. p. 268) and others. Darwin was of opinion that the discs of *Bignonia capreolata* Linn. (Bignoniaceae) and *Hanburya mexicana* Seem. (Cucurbitaceae) also secrete some sort of adhesive resinous cement. But, perhaps, it may be stated here that, up to this time, the writer has not come across any direct or convincing evidence to show that, the trichomes and papillae, constituting the anchoring pads of *Gymnopetalum cochinchinense* Kurz actually secrete any mucilaginous or resinous substance to glue the pads to the substratum of the support. Nevertheless, it is quite likely that, they do—although the quantity, considering the size of the pads, must necessarily be quite small. On the other hand, the presence of the turgid cells (see figs. D and E) of the papillae and trichomes, the branching (see fig. F) that occasionally takes place in the latter, and the nice way in which they fit themselves into the crevices, lead the author to suspect that, the process of attachment, at any rate, in the case of *Gymnopetalum cochinchinense* Kurz, is probably, at least partly, physical.

The development of these pads of *Gymnopetalum cochinchinense* Kurz, under adverse circumstances, where ordinary coiling-tendrils are of no use, seem to indicate that, among tendril climbers—which occupy a high place in the scale of organization—there are, at least, some plants, which are endowed with means of 'Double Adaptation. These plants, if placed under adverse circumstances, seem to take recourse to means (*e.g.* pads) which can be looked upon as alternative to the usual one (*i.e.* coiling-tendrils).

It will not perhaps be out of place to mention here that, although, some climbing and epiphytic plants (*e.g. Pothos angustifolius* Presl., *P. aurea* Linden., *Cymbidium aloifolium* Sw. and *Vanda Roxburghii* Br. etc.) are endowed with roots, which have the power of fixing themselves to supports, with the aid of capillary outgrowths from their epidermal cells, the papillae and multicellular trichomes met with on the anchoring pads of *Gymnopetalum cochinchinens* Kurz, *when examined microscopically*, could never be confounded with those unicellular capillary structures, which are, in fact, hardly distinguishable from the ordinary underground root-hairs, except in colour. It should also be stated here that, the adhesive-discs of *Vitis assamica* Laws., like those of *Ampelopsis quinquefolia* Michx. (= *Vitis hederacea* Ehrh.) (**3** pp. 144-149), are composed of hypertrophically-enlarged globular cells with smooth hemispherical surfaces.

These globular Cells are quite different from the papillae and multicellular trichomes of *Gymnopetalum cochinchinense* Kurz. in both appearance and structure.

In conclusion, it may be added here that, among Cucurbitaceous plants, such anchoring pads have been also clearly noticed by the author, in dried specimens of *Trichosanthes palmata* Roxb. There are a few plants *e.g.*, *Trichosanthes cucumerina* L., *Luffa aegytiaca* Mill. and *L. acutangula* Roxb. in which such modification of tendrils into anchoring pads is suspected. In a few other plants *e.g.*, *Trichosanthes cordata* Roxb., *T. dioica* Roxb. *Momordica dioica* Roxb., *M. cochinchinensis* Spreng., *Cucumis sativus* L., *Citrullus vulgaris* Schrad., *Cephalandra indica* Naud., *Cucurbita moschata* Duch., *Mukia scabrella* L. f. and *Zehneria umbellata* Thw.. the slight thickening noticed in some portions of tendrils in contact with their supports, seem to suggest that, as a result of stimulation due to contact, the cells on the affected side suffer only from a moderate degree of hypertrophy. No thickening even has been observed in specimens of some plants *e.g.* *Lagenaria vulgaris* Ser., *Benincasa cerifera* Savi., *Momordica Charantia* L. and *Cucumis trigonus* Roxb., examined by the author. The majority of these plants are of tropical origin and the rest are cultivated in the tropics. The writer regrets that, he had to base his conclusions, regarding the plants mentioned in this paragraph, on dried specimens.

Explanation of Figures

(*Figures B-F drawn without the aid of a Camera Lucida. Magnifications approximate.*)

Fig. A.—A branch of *Gymnopetalum cochinchinense* Kurz. Nat. size. a, b, & c—anchoring pads, d—coiled portion of a tendril, t—tendril.

Fig. B.—An isolated pad. x 6.

Fig. C.—An anchoring pad growing in a crevice. x 35, n—nucleus, pap.—papilla, pap'.—trichome.

Fig. D.—A part of a longitudinal section of an anchoring pad showing enlarged trichomes. x 250, n—nucleus, n'—nucleolus, pap.—papilla, pap'—trichome.

Fig. E.—Transverse section of a pad growing in a crevice. x 170. Ep.—epidermal cell, n—nucleus, pap.—papilla, pap.'—trichome.

Fig. F.—An artificial group of some of the branched trichomes from a pad growing in a crevice. x 170. e & f.—branched cells, Ep.—epidermal cell, n—nucelus, pap.'—trichome.

List of Books and Papers consulted

(This list is not exhaustive.)

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2. Cogniaux.—Cucurbitacees Nouvelles (1887).
3. Darwin.—The Movements and Habits of Climbing Plants—Murray's Pop. Ed. (1906).
4. Goebel.—Organography of Plants. Eng. Ed. Vol. I (1900), Vol. II (1905).
5. Green.—Manual of Botany—Vol. I, 3rd Ed. (1904), Vol II., 2nd Ed. (1902).
6. Haberlandt.—Physiological Plant Anatomy. Eng. Ed. (1914).
7. Jeffrey.—Anatomy of Woody Plants (1917).
8. Kerner and Oliver.—Natural History of Plants. Vol. I (1894).
9. Le Mout and Decaisne.—Descriptive and Analytical Botany. Eng. Ed. (1873).
10. Lindley.—Vegetable Kingdom, 3rd Ed. (1853).
11. Muller and Pax.—Cucurbitaceae in Pflanzenfamilien, IV. 5. (1894).
12. Pfeffer.—Physiology of Plants. Eng. Ed, Vol. I (1900), Vol. II (1903).
13. Pfleiderer.—Glimpses into the life of Indian Plants. 3rd Ed. (1916).
14. Roxburgh.—Flora Indica. Clarke's Ed. (1874).
15. Sachs.—Text Book of Botany. 2nd Ed. (1882).
16. Schimper.—Plant Geography. Eng. Ed. (1903).
17. Seringe.—Memoire sur les Cucurbitacees (1824).
18. Solereder.—Systematic Anatomy of the Dicotyledons. Eng. Ed. Vols. I and II (1908).
19. Strasburger.—Text Book of Botany.—4th Eng. Ed. (1912).
20. Uhlworm.—Beit. zur Entwicklungsgeschichte de Trichome... Bot. zeit. (1873).
21. Vines.—Physiology of Plants (1896).
22. Warming.—Oecology of Plants, Eng. Ed. (1909).
23. Wight.—Illustrations of Indian Botany (1890).
24. Yasuda.—Comparative Anatomy of the Cucurbitaceae etc. Journ. Coll. of Sc. Imp. Acad. Univ. Tokyo. XVIII (1903).

The author regrets that he could not consult some interesting contributions *e.g.* Van Tieghem's Sym. de struct., in Ann. Sc. Nat. Ser. 5.t. xiii (1870-1) and Tondera's Gefässbundelsyst. d. Cucurbit sitz. in Ber. Weiner Akad., cxii. Abt. 1 (1903) and a few others, as these were not available to him.

THE INDIAN OPHIOGLOSSUMS

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There is a considerable amount of confusion in the treatment of the Genus Ophioglossum. The extreme variability of the individuals comprising the different species has been the fruitful parent of a large number of spurious species. In the following article the Indian Ophioglossums are treated, and an attempt is made to mark their limits.

Beddome in his "Handbook to the Ferns of British India, Ceylon and the Malay Peninsula" describes 5 species, *O. vulgatum* L., *O. nudicaule* L., *O. fibrosum* Schum., *O. reticulatum* L. and *O. pendulum* L. In his supplement to the same book he adds O. gramineum Willd., which I take to be a form of *O. lusitanicum* L.

O. vulgatum and *O. reticulatum* are inseparable from each other. I have lumped them together under the common name *O. vulgatum*. The rest of the Indian Ophioglossums are distinct species, though Beddome suspects *O. nudicaule* to be a form of *O. gramineum*. I add one more species, *O. Aitchisoni* Sp. Nov. which brings the total of Indian Ophioglossums to six.

It will be worth while at the outset to bear in mind that previous descriptions have been vitiated by the length of the stipe or the distance of the sterile division of the frond from the rhizome being recorded. This length seems to me to be of no systematic importance, as it varies with the depth of the rhizome in the soil. I have therefore not taken it into consideration.

(1) **Ophioglossum vulgatum** L.—Hook, Syn. Fil, pp. 445 and 446; Bedd F.S.I. t. 70. O. reticulatum *L.*, O. cordifolium *Roxb.*, O. petiolatum *Hk. Ex. F.*, O. pedunculosum *Desv.*

I have compared a good number of sheets both Indian and European and am convinced that they are merely forms of the same species being connected by a number of transitional stages. From earlier descriptions only the following points of difference between O. vulgatum and O. reticulatum can be made out.

O. vulgatum *L.*, Sterile division not cordate at the base, without a distinct haft.

O. reticulatum *L.* Sterile division distinctly cordate at the base, provided with a distinct haft. The following instances will show that these characters are not constant.

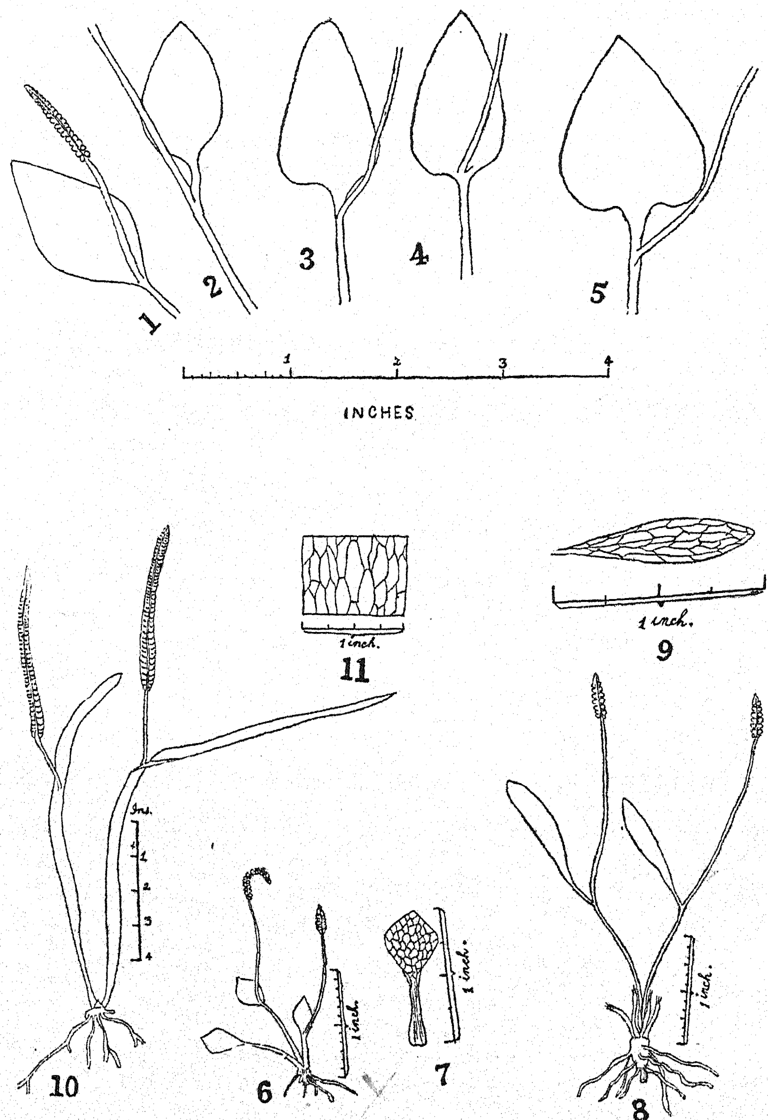


Fig. 1. Typical Ophioglossum vulgatum.

Figs. 2, 3 & 4. Transitional stages between O. vulgatum and O. reticulatum.

Fig. 5. Typical O. reticulatum.

Fig. 6. Ophioglossum undicaule L. Fig. 7. Venation of same.

Fig. 8. Ophioglossum lusitanicum L. Fig. 9. Venation of same.

Fig. 10. Ophioglossum pendulum L. Fig. 11. Venation of same.

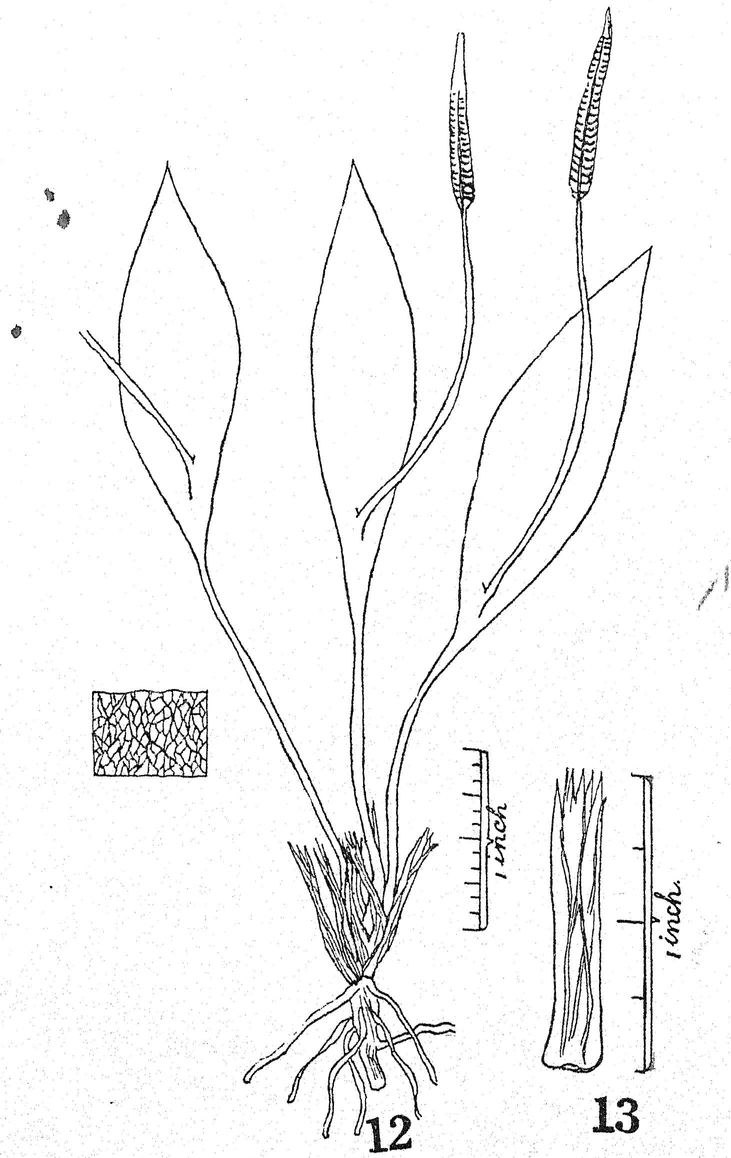


Fig. 12. Ophioglossum Aitchisoni sp. nov.
Fig. 13. One of the sheaths surrounding the bases of the fronds.

1. Leg. Gamble 1895 (Herb. Hort. Bot. Calcuttensis).

Loc. Kathian Jaunsar 7,000 ft. Sterile segment ovate-lanceolate obtuse mucronate, not cordate.

There is a distinct haft in one frond and no haft in another arising from the same rhizome.

2. Leg. Gamble 1895. (Herb. Hort. Bot. Calcuttensis).

Loc. Kathian Jaunsar, 7,000 ft.

There are six fronds on this sheet. In one of them the sterile division is distinctly cordate at the base and provided with a distinct haft; the others are not cordate at the base but with hafts.

3. Leg. P. W. and V. A Mackinnon 1885. (Herb. Hort. Bot. Calcuttensis).

Loc. Mussorie, The Park, 6,000 ft.

Sterile division ovate, acute or obtuse mucronate, slightly cordate, haft distinct.

4. Leg. P. W. Mackinnon 1880. (Herb. Hort. Bot. Calcuttensis).

Loc. Mussorie, Park Tank.

There are four fronds on the sheet, ovate, acute or obtuse; one of them distinctly hafted but not cordate; another neither cordate nor provided with a haft.

5. Leg. P. W. Mackinnon, 1880. (Herb. Hort. Bot. Calcuttensis).

Loc. Mussorie, Park Tank.

In one frond, the sterile division is lanceolate, with a distinct elongated haft sheathing the base of the fertile segment, but it is not cordate. Another frond is cordate at the base.

6. Leg. Clarke 1883. (Herb. Hort. Bot. Calcuttensis).

Loc. Parasnath, Hararibagh, 3,000 ft.

Sterile division lanceolate-ovate, acute or obtuse, base not cordate or slightly so suddenly truncate and passing into a very much elongated haft sheathing the base of the fertile peduncle.

7. Leg. Shaik Mokim 1897. (Herb. Hort. Bot. Calcuttensis).

Loc. Kachin Hills, Upper Burma.

Sterile division ovate acute, not cordate but provided with a haft.

8. Lace 1908. (Herb. Hort. Bot. Calcuttensis).

Loc. Upper Chindwin District, Burma.

There are two plants on the sheet with three fronds each :—

(1) Sterile divisions of 2 fronds ovate, acute, cordate at the base and hafted, the remaining one elliptical hafted, not cordate.

(2) Sterile division of one frond ovate, acute, cordate at the base and hafted; of another elliptical, not cordate and without a haft. The third frond is sterile.

9. Leg. ? 1891. (Herb. Hort. Bot. Calcuttensis).

Loc. Singapore, Malay Peninsula.

Four plants on the sheet :—

(1) Sterile division lanceolate-ovate, acute, not cordate, no distinct haft.

(2) In 2 plants sterile division ovate acute distinctly hafted, not cordate.

(3) In the 4th plant sterile division hafted and approximating to cordate.

10. Leg. Brandis (Herb. Hort. Bot. Calcuttensis).
Loc. Burma.

Four solitary fronds and 4 whole specimens on the sheet. Sterile divisions of the solitary fronds ovate acute cordate, with distinct hafts, sheathing the bases of the fertile divisions. In the whole plants the sterile divisions are either ovate, obtuse, cordate at the base and hafted or sub-reniform and distinctly hafted. There are also sterile fronds with laminae sub-reniform, being cordate at the base or orbicular and not cordate at the base.

11. Leg. Craib 1908 (Herb. Hort. Bot. Calcuttensis).
Loc. Haflong 2,500 ft. Assam.

Sterile segments ovate or elliptical ovate obtuse or mucronate, with distinct hafts, but by no means cordate.

12. Leg. Fischer 1905 (Herb. Hort. Bot, Calcuttensis).
Loc. Doddasampagai, 3,000 ft. Coimbatore.
Sterile segment ovate, acute or obtuse, cordate at the base and distinctly hafted. (Typical reticulatum).

13. Leg. Prain, 1889 (Herb. Hort. Bot. Calcuttensis).
Loc. Sureil, Sikkim.

Sterile division ovate, acute or obtuse, or oblong, no haft, not cordate (Typical vulgatum).

The European specimens in the Calcutta Herbarium are typically vulgatum, but in a few the haft is present, in one the base of the sterile division is distinctly cordate,

The following is an expanded description intended to embrace the hitherto separate species O. vulgatum and O. reticulatum :—

Rhizome cylindrical elongated; sterile division of frond 1-4 inches long, ½-2 inches broad, ovate, ovate-oblong, lanceolate, blunt, acute, or mucronate at the apex, often distinctly cordate at the base with or without a distinct haft; veins clear, often scarcely visible, no midrib; fertile spike 1 inch or more long on a peduncle 2-6 inches long.

Distribution :—*Bengal* : Parasnath, Hariribagh. 3,000 ft. M. Davies.

Assam :—Dhubri-Gauhati Grand Trunk Road, Goolpara Dist. 200 ft., Marten; Haflong, 2,500 ft., Craib.

Sikkim :—Sureil, 5,200 ft. Prain; Goak, 4,000 ft. Anderson.

United Province :—Mussorie, The Park, Park Tank 6,000 ft.—6,500 ft. Mackinnons; Kathian Jaunsar 7,000 ft. Gamble; in the Dun—Kalanga Hill near Dehra 3,000 ft., Gamble.

Chamba State :—Punjab : Kantli, 12 miles from Dalhousie 6,500 ft.

Simla Reg.:—Hattu Mt. 8-9000 ft.; Bagi (Hattu Mt.), Hope.

Rajputana:—Mount Abu, Blatter.

Bombay Presidency:—Karwar, 500 ft. Sedgewick and Bell.

Madras Presidency:—Doddasampagai, Coimbatore, Fischer; Nilgiris and Anamallayas 2,000 ft. and upwards (Bedd.); Travancore Lawson.

Burma:—Upper Chindwin District, Lace; Kachin Hills, Shaik Mokim.

Malay Peninsula:—Singapore.

Malay Islands; Polynesia; Europe; Africa and its islands; America; Japan; Sandwich Islands; Phillipines, Australia; New Zealand.

(2) **Ophioglossum Aitchisoni** Sp. Nov.—O. vulgatum *L. Var.* Aitchisoni *C. B. Clarke* (in "Review": 586); O. lusitanicum *L.* (C. W. Hope "Ferns of North Western India" in the Bombay Natural History Society's Journal Vol. XV. p. 106).

Rhizome elongated, not tuberous with several fibrous rootlets and crowned with a tuft of brown persistent sheaths surrounding the bases of the fronds; fronds several on the rhizome, sterile division $1\frac{1}{2}$-$2\frac{1}{2}$ inches long, $\frac{1}{2}$-$\frac{3}{4}$ inch broad, linear lanceolate, acute or mucronate; Veins visible in dry specimens, but not quite distinct; no midrib; texture stout; fertile division arising from a little above the base of the sterile lamina, fertile spike 1 inch long on a peduncle 2 inches long.

Distribution:—*N. W. Himalayas*, Cherat 9,000 ft., H. Collet, 1892; Mount Tilla, Dr. Aitchison 1874 and 1880.

Bombay Presidency:—Siroor Horse breeding Farm, Chakradeo, 1920.

Africa: Abyssinia (Labelled O. nudicaule *L. in Herb.* Hort. Bot. Calcuttensis).

Clarke's O. vulgatum *var.* Aitchisoni which Hope in the "Ferns of North Western India" published in Vol. XV p. 107 of the Bombay Natural History Society's Journal places under O. lusitanicum is this fern. The brown persistent sheaths, about an inch long, more or less jagged at the extremities and strengthened by longitudinal strands are very characteristic. They seem to be the withered remains of the stipes of older fronds and resemble very much the sheaths occurring in Botrychium lunaria Sw.; but whatever their nature may be, the fact that they are persistent cannot be overlooked. At the bases of the fronds of O. vulgatum a couple of papery sheaths may be detected, but these are very deciduous and do not compare in size and texture with the persistent sheaths of this fern. Similar sheaths, though fewer in number also occur in O. lusitanicum and that is why perhaps Hope places this fern under that species. But O. lusitanicum is a much

smaller fern with the sterile division almost spathulate and the fertile division arising quite at the base of the sterile and not from its lamina.

(3) **~~O. nudicaule~~** L.—O. parvifolium *Hook. and Grev.*

I believe the true O. nudicaule is a much smaller fern than is described in Hooker's Synopsis Filicum. The dimensions given by Beddome and his figure T. 71 F. S. I. confirm this view. At least they hold good for all the Indian specimens I have examined except that the venation is rather clear. Sheaths are wanting on the rhizome. In a few specimens from Khandala the stipes are remarkably flattened. Bed. H.B. p. 464. Hook. Syn. Fil. p. 445 (in part ?).

Distribution :—*Malay Peninsula* : Topa : Perak, Wray.

Bombay Presidency :—Castle Rock, Sedgwick and Bell, 1918; Khandala, Blatter and Hallberg 1919.

South India :—Anamallay Forests 2,500 ft. and elsewhere on the Western Mountains (Bedd).

America from United States southwards to Brazil, New Caledonia and Tropical Africa.

(4) **O. lusitanicum** L.—O. azoricum *Presl.* O. gramineum. *Willd*; Hook. Syn. Fil. p. 445. Rhizome slightly tuberous bearing a few brown sheaths; sterile division $\frac{1}{2}$–$1\frac{1}{2}$ inches long, $1\frac{1}{2}$–2 inches broad, lineo-lanceolate bluntish at the apex, approximating to spathulate, narrowed down into a distinct petiole where it unites with the fertile division; veins invisible, no midrib; texture thick; spike $\frac{1}{4}$–$\frac{1}{2}$ inch long on a firm peduncle about 2 inches long.

Distribution :—There is only one sheet in the Calcutta Herbarium purchased from N. Dalzell in 1878. The Indian locality is not mentioned; the covering sheet bears the inscription " Peninsular India and Ceylon."

Beddome in his supplement to the Handbook F.B. I mentions the following localities for O. gramineum *Willd* (which I consider a variety of his fern.) :—

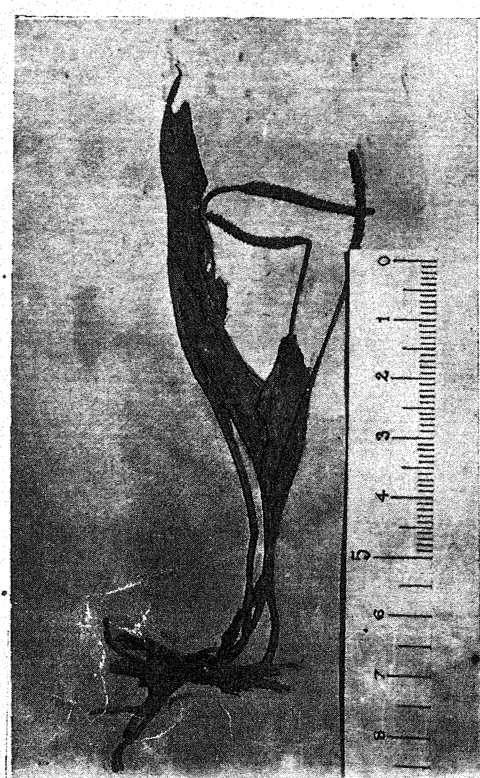
" South India :(Wight); Calcutta, Lucksagar (Watt); Ceylon; Unia-Oya, Central Provinces (Trimen)."

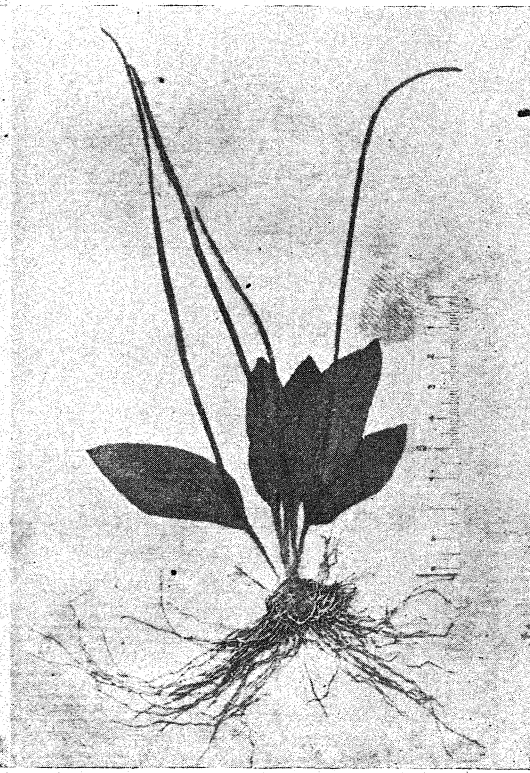
Shores of the Mediterranean as far as Guernsey; Azores Madeira; Guinea Coast.

This form is distinguished from O. nudicable by (1) the shape of the sterile division (2) the presence of persistent brown sheaths on the rhizome (3) the thick texture, invisible veins and firm peduncle.

(5) **Ophioglossum fibrosum** Schum.—O. Wightii *Hook. & Grev*; O. brevipes *Bedd.*

Distribution :—*Bengal*, Manbhum, J. Campbell; *Bombay Presidency* :—Khandala.





OPHIOGLOSSUMS AITCHISONI Sp. Nov. OPHIOGLOSSUMS FIBROSUM Schum.

The Scales are in Centimetres.

Ceylon?—Thwaites. *South India,* Anamallay Teak forests 2,000—3,000 ft. Also—Tropical Africa, Guinea Coast; Ascension Island.

This is the only Indian Ophioglossum in which the midrib is prominent and remains as a pale white streak even in dried up specimens. This evident midrib and the large round tuberous rhizome with fibrous rootlets and having a deep depression on the top for the insertion of the fronds are sufficient to distinguish this fern from the preceding ones.

(6) **O. pendulum** L.—O. intermedium *Hk.* (Syn. Fil, p. 446, Bedd H. B. p. 467).

The size of the fronds is very variable likewise also the insertion of the fertile segment which is below the centre of sterile segment in some specimens and quite high up near the apex in others. Beddome has "veining not distinct". In all the specimens seen by me the veining is quite clear.

Distribution:—*Malay Peninsula,* Kuntsler 1880: Perak, Wray Jr.

Burma:—Moulmein.

Assam:—Makum forest; Lukkimpore.

Ceylon:—Thwaites.

Malay and Polynesian Islands; Mauritius; Australia; Phillipines.

Key to the Species

A. Fertile spike arising at or quite near the base of the barren segment.

  1. Rhizome elongated cylindrical, not tuberous.
     (*a*) No persistent sheaths on the rhizome. O. vulgatum.
     (*b*) Persistent brown sheaths present on the rhizome.................................. O. Aitchisoni.
  2. Rhizome somewhat tuberous.
     (*a*) No persistent sheaths on the rhizome. O. nudicaule. (9r)
     (*b*) Persistent brown sheaths present on the rhizome.................................. O. lusitanicum.
  3. Rhizome distinctly tuberous in the form of a large round tuber........................ O. fibrosum.

B. Fertile spike arising far above the base of the barren segment.................................. O. pendulum.

I take this opportunity to thank the Curator of the Calcutta Herbarium, Dr. Burns of the Agricultural College Poona, and Mr. L. J. Sedgewick for placing their material at my disposal.

A CASE OF AXIAL FLORAL PROLIFICATION OF THE FLOWER OF NYMPHAEA RUBRA *Roxb.*

BY

P. M. DEBBARMAN, B.SC., F.L.S.

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Among the specimens preserved in the Calcutta Herbarium, there is a curious specimen (Fig. A) of *Nymphaea rubra* Roxb, collected in 1895 by Abdul Khalil, a plant collector, in S. Shan States, Upper Burma, This specimen appears to be worth placing on record, as an example principally of axial floral prolification of the flower and phyllomorphy of the stamens.

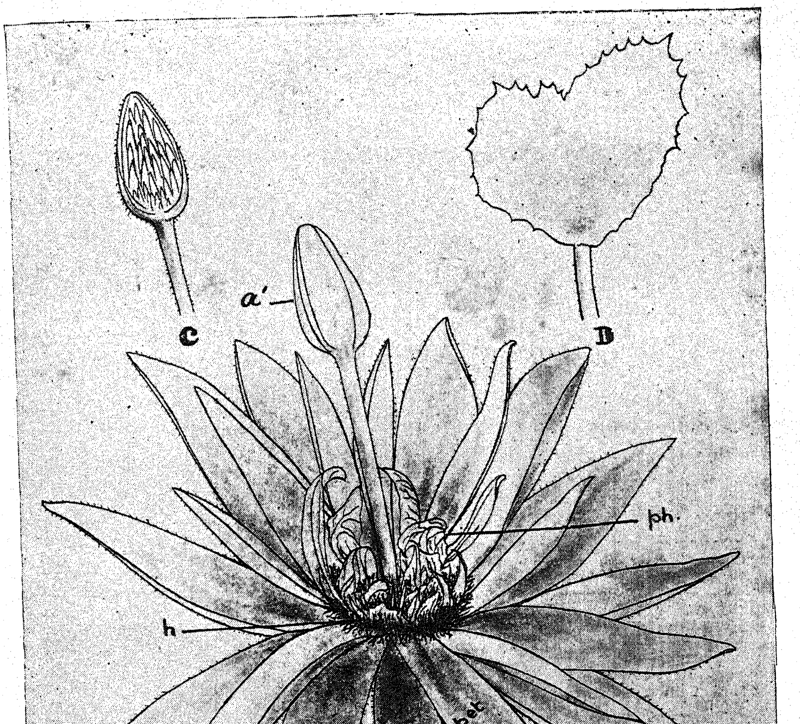
Fig. B, representing the median-longitudinal section of the main flower *a*, clearly shows that supernumarary flower *a'* has proceeded from the axil *x* of one of the petals *pet*. The stamens have undergone so much perverted development that these have become transformed into leaf-like structures *ph*, thus exhibiting phyllomorphy. This latter change is very striking in view of the fact that, the structure of an anther is usually far removed from that of an ordinary leaf, and this reminds us of Goethe's " Theory of Retrograde Metamorphosis ". In place of the many-celled glabrous ovary and the disk, we find a hard structure G', filled up with a brownish yellow mass and covered all over with intricate woolly hairs *h*, which are interspersed not only among the transformed leafy stamens *ph*, but also among the inner petals *pet*.

Fig. C of a longitudinal section of the supernumerary flower (a' in Fig. B) shows the transition of the petals into stamen-like structures devoid of any trace of anthers. No trace of any ovary is visible.

Fig. D shows that the leaves have not only become considerably reduced in size, but, altered in shape too.

In page 143 of his well-known 'Vegetable Teratology' Masters has cited, with figure, a specimen (grown in the aquarium at Syon House) originally described and figured in 'Gardener's Chronicle' (1855), P. 548. Although, there is a good deal of resemblance between the two specimens, still, there are some points of difference which are worth noticing below.

In the Burma specimen—(1) the scape *Sc* is free from the least sign of any torsion; (2) the supernumerary flower a' has apparently proceeded from the axil of a petal instead of that of a stamen; (3) a



a'
C
D
ph.
h
pet
a
a'
Sc
P.M.D. & F.B.D.
Nymphæa rubra Roxb.
A
ph
h
pet
G'
x
a'
Sc
B
(Reduced)

dense growth of fairly long matted hairs covers the whole upper surface of the structure G', representing the disk and the missing ovary; and (4) the leaves have suffered a considerable change in size and shape.

It seems quite probable that, two different kinds of factors—one 'internal' and the other 'external'—might have been at work here, giving rise to these structural deviations. On the one hand, the presence of the supernumerary flower and the change in the shape and size of the leaves, lead one to suspect that these might have been due to some 'internal' cause or causes; and, on the other hand, the presence of a brownish mass in the structure G', and of the hairs on it, lead one to suspect that some 'external' factor (*e.g.*, a parasite might have been responsible for these.

No further explanation of the figures seems to be necessary.

NOTES ON SOME FOREIGN PLANTS WHICH HAVE RECENTLY ESTABLISHED THEMSELVES ABOUT LAHORE

By Shiv Ram Kashyap, B.A., M.Sc.,

Read before the meeting of the Indian Science Congress at Madras, 2nd February, 1922.

The indigenous flora of the country round about Lahore is more or less that of a desert. The commoner plants met with in dry places are the following :—*Salvadora oleoides, Capparis aphylla, Tamarix articulata, T. dioica* (on the river side), *Salsola foetida, Kochia indica, Atriplex crassifolia, Aerua javanica, Lippia nodiflora, Trianthema crystallina, Mollugo hirta, Portulaca quadrifida, Solanum xanthocarpum, Polygonum plebeium, Euphorbia prostrata* and a number of Cyperaceae and Graminaceae. All these plants are characterised more or less by xerophilous features. During recent years, however, irrigation by canals has modified the vegetation very greatly. Quite a large number of weeds, more or less delicate, are met with in cultivated places, fields, gardens and other moist localities. A good many of these must have been present in fields even before the introduction of canals but the latter have undoubtedly increased the number of individuals and species growing in cultivated places. Apart from these plants growing in moist places many others have been and are being introduced from other countries with climate similar to that of the Punjab plains and some of these which have established themselves in this way on the ordinary unirrigated soil are quite well known. Among these may be mentioned, *Opuntia Dillenii, Argemone mexicana, Erigeron linifolium,* and *Tridax procumbens,* all of which are mentioned by Hooker in Flora of British India.

Apart from general works on the vegetation of India, like the Flora of British India by Hooker and Indian Trees by Brandis, and other local floras of different parts of the country which mention Punjab plants incidentally, there are not many books dealing with the plants occurring in the Punjab. Aitchison's Catalogue of Punjab Plants, Stewart's Punjab Plants (both published in 1869), Bamber's Punjab Plants, Parker's Forest Flora of the Punjab, and some publications of the Botanical Survey of India may be mentioned in this connection. Duthie's Flora of the upper Gangetic plain may be specially men-

tioned as it deals with a neighbouring region. Some three years ago Parker prepared a paper on the vegetation of the central Punjab but the writer has no access to the paper. Probably it has not been published so far. The writer has been observing the local flora for some years and has found that a number of new plants are gradually establishing themselves round about Lahore. Some of these have been recorded by Parker in his Forest Flora of the Punjab, while others have not so far been recorded. A list of such plants is therefore given in this paper.

1. *Ranunculus sardous*, Crantz. Not described in any of the Indian Floras. Perhaps not an introduced plant but has been overlooked. It is very much like the common *R. pensylvanicus* but has not got the spreading hairs of the latter. Quite common in Lahore in some places, especially near the riverside. Mentioned by Boissier in Flora Orientalis.

2. *Senebiera didyma*, Pers. Extremely common in winter and summer. Not included in the Flora of Br. India. Mentioned by Duthie.

3. *Viola Patrinii*, DC. Fl. Br. Ind. gives Temperate Himalaya as its distribution, from 4,000 ft. to 8,000 ft. Does not mention the Punjab plain. Duthie does so. Occasionally seen in Lahore.

4. *Sagina apetala*, L. An annual occurring in western Asia and Europe. Hooker describes it in his Flora of the British Isles. Obviously imported from Europe. The allied species *S. procumbens*, L. is a perennial and is distributed in north-western Asia to the Himalayas and Europe.

5. *Oxalis pes-caprae*, Linn. Introduced within the last few years from America. Not generally cultivated, still quite common in cultivated places, conspicuous with its large yellow flowers. Must be an escape originally but is fairly well-established now. Flowers February to April.

6. *Oxalis corymbosa*, DC. Flowers March—May. Larger leaves and larger flowers than those of the former species. Flowers pink. Also American. No doubt an escape but fairly well-established in cultivated places though not so common as the former species. Both form bulbs but do not set seeds at Lahore. Calder and Ramaswami have also pointed out how some foreign species are establishing themselves in India in a paper read before the Science Congress at its fourth session.

7. *Desmanthus virgatus*, Willd, and

8. *Leucaena glauca*, Benth. Both American, and mentioned by Parker. No. 8. also mentioned by Duthie.

9 & 10. *Opuntia sp.* Burkill in a recent paper in the Records of the Botanical Survey of India describes the distribution of the species of *Opuntia* in India and traces the history of their introduction. *Opuntia Dillenii*, Haw, is quite common in Lahore. *O. stricta*, Haw., under which Burkill includes *O. monacantha* Haw., also, is quite common. It is however *O. stricta* and *O. monacantha* does not appear to be at all common. One more species is gradually becoming common but has not been identified as yet. Parker gives both the species mentioned here. They are all American.

11. *Hydrocotyle rotundifolia*, Rox. Mentioned by Hooker and Duthie as occurring in the Western Himalayas and Bengal plain. Does not occur in Europe. The plant is met with in large patches in gardens generally irrigated by the canal water. I think it is a clear case of a plant being brought from the hills by the rivers and later on by the canals.

12. *Ammi Huntii*, Wats. Is not given in Fl. Br. Ind. or Duthie. Even Hooker does not include it among the indigenous plants of the British Isles. A native of Azores. Obviously imported from Europe. Occurs in the Lawrence Gardens.

13. *Lactuca scariola*. L. According to Fl. Br. Ind. distributed in the Western Himalayas 6-11000 ft. Occurs in Br. Isles also. Not given by Duthie. Probably another case of a plant brought from the hills through the canals. Or perhaps imported from Europe. *L. sativa* is given as a variety in Fl. Br. Ind.

14. *Nicotiana plumbaginifotia*, L. A common weed in Bengal (Fl. Br. Ind.) Duthie does not mention it. Quite common here.

15. Ruellia tuberosa, L. Not mentioned in Fl. Br. Ind. or Duthie. American. Occasionally met with in cultivated places as an escape.

16. *Verbena bonariensis*, Linn. A native of Brazil and according to Fl. Br. Ind. naturalised in the Himalayas. Not mentioned in Duthie. Often met with along the canal.

17. *Euphorbia geniculata*, Orteg. According to Fl. Br. Ind. occurs as an escape in some places. Originally American. Often met with in the Lawrence gardens.

18. *Eichhornia crassipes*, Solms, the water hyacinth. Not given in Fl. Br. Ind. or Duthie. Sometimes occurs in enormous numbers in ponds. As is well known the plant is a pest in Bengal.

19. *Nothoscordum fragrans*, Kunth. A case of very recent introduction. Originally a native of Europe, Africa and Asia minor. During the last two or three years has been found growing in large numbers in lawns and cultivated places in gardens. Obviously an escape but is sure to become firmly established. Forms bulbs.

From the above it will be seen that whereas some plants have established themselves owing to the suitability of the climate of the Punjab plain, others are merely weeds of cultivation. The *Opuntias*, *Verbena bonariensis* and many of the older established plants belong to the former group, while the great majority of the rest are merely weeds of cultivation.

Again a few plants have undoubtedly been brought from the hills, e.g., *Hydrocotyle rotundifolia* and probably also *Lactuca scariola*, others have come from abroad. It is interesting to note that most of these plants are American.

Many of these plants were compared at the Royal Botanic Carden Herbarium at Calcutta by the kindness of Mr. Calder to whom my thanks are due.

AUTONOMOUS MOVEMENTS IN ELEIOTIS SORORIA *DC.**

(With two figures in the text.)

BY W. T. SAXTON, F.L.S.

1. Introduction

When fully grown, *Eleiotis sororia* is a considerably branched herb, and the branches trail along the ground amongst other vegetation to a length of a yard or so. It is usually found in more or less shady localities. It was only known to the writer from Herbarium specimens until October, 1921, when a very considerable number of large, healthy plants was met with on a small hill in Devgad Baria State, in the Panch Mahals. It is probably fairly widely distributed in xerophytic woodland. It also occurs in North Gujarat in cultivated fields, under the shade of crop plants or hedges, and some four separate localities are known to the writer where it is to be found, though only one of these is within easy reach of Ahmedabad. Several attempts have been made to cultivate the plants, with some degree of of success, but they do not grow very readily from transplanted specimens, and no seedlings have been raised at present.

Cooke, in his 'Flora of the Bombay Presidency' (1903), says that *Eleiotis sororia* is a rare plant in the Presidency, but from the facts given in the preceding paragraph this would appear not to be the case.

From the descriptions one would also conclude that the leaves are only exceptionally trifoliolate. This also is inaccurate. Small and stunted plants may seldom develop the small lateral leaflets, but in large, healthy plants a considerable majority of the leaves possess them, though some have only one of the pair and others have no trace of lateral leaflets whatever.

It is surprising that there is apparently no record of the remarkable movements executed by these leaflets having been observed before, though the only other plant (so far as the writer can ascertain) in which similar movements are met with—namely the "Telegraph plant", *Desmodium gyrans* DC.,—has been well-known to Botanists for half a century at least, and has been repeatedly studied. The most complete recent account of the movements of *Desmodium gyrans* is given by Sir J. C. Bose, in his "Researches on irritability in plants"

* A preliminary announcement of these movements was read at the joint meeting of the Indian Science congress (Botany section) and Indian Botanical Society at Madras, in January, 1922.

(1913), but many other references to it are found in the earlier literature.

Consequently, when similar movements were first seen in *Eleiotis* at Devgad Baria, the hasty and erroneous conclusion was drawn that the plants under observation were specimens of *Desmodium gyrans*, and it was only after comparing specimens with descriptions some hours later that it was found they were not. It was not possible to revisit the Baria locality, but in December, 1921, a clump of plants was discovered within two miles of Ahmedabad in a moribund condition. Early in August, 1922 this place was visited again, and three or four dozen healthy young plants were found. They were seen in the early morning and showed little movement. From observations at all hours on transplanted specimens it seems that the movement is not conspicuous in the morning but gradually increases in amplitude. Consequently the locality was revisted at 6 p.m. on August 13, and the following observations recorded.

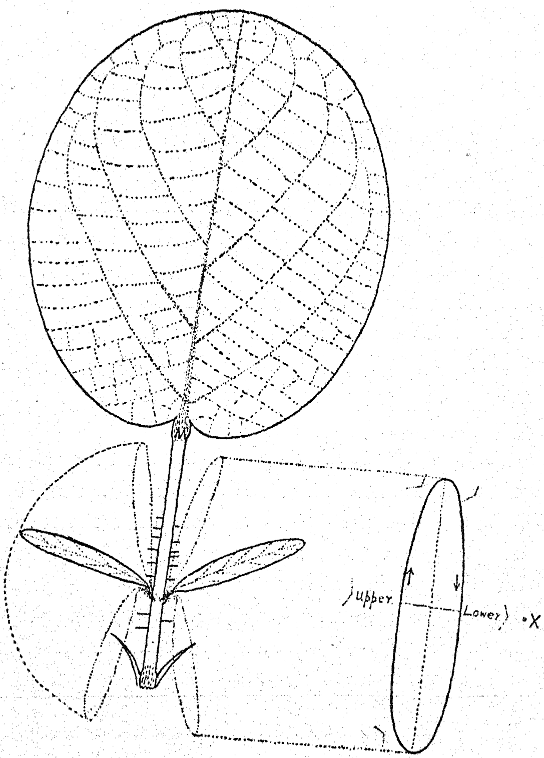


FIG. 1.

Fig. 1.—Leaf of *Eleiotis sororia* DC., showing the nature and amplitude of the autonomous movements of the lateral leaflets. For explanation see text × 2.

2. Observations

The young plants are erect. Those on which observations were made were about one foot high, and nearly all the leaves were trifoliolate. Figure 1 shows the form of a typical leaf detached from the plant and looked at from a point perpendicular to the adaxial surface. The

lateral leaflets are shown in the mean position, while the extreme 'up' and 'down' positions are shown by dotted outlines, and the apparent path of the tip as seen from this view-point is also indicated by a dotted line on the left of the figure.

The petiole slopes up from the stem at an angle of about 40°—50° to the horizontal. The terminal leaflet is spread out by day nearly horizontally, or sloping somewhat downwards, thus making an angle of about 110°—120° with the petiole. By night the large leaflet hangs down vertically, with very little change in the position of the petiole, the lamina thus making an angle of 40°—50° with it.

The lateral leaflets move up and down,* parallel to the petiole, as indicated in the figure, in very much the same manner as those of *Desmodium gyrans*, and when looked at from the direction of the point X (on the extreme right of the figure) the tip of the leaflet is seen to move in a curve (defined more fully on a later page) of which the orthogonal projection is shown towards the right of the figure. The projection has the form of an ellipse the major axis of which lies parallel to the petiole and is usually four to five times the length of the minor axis, the latter being perpendicular to the plane of the leaflet lamina in its mean position.

The temperature at the time of these observations was not observed, but cannot have been much removed from 28° C. A complete period of revolution of the tip of the leaflet was found, from several observations on different plants, to vary in frequency from 120—130 seconds, the majority having a period of almost precisely 125 seconds. The complete period is made up approximately as follows, the corresponding figures for *Desmodium gyrans*, calculated from curves given by Bose (loc. cit.), being added for comparison.†

—	ELEIOTIS SORORIA	DESMODIUM GYRANS.
Downward movement ...	15—30 secs.	23 secs.
Rest	50—35 „	26 „
Upward movement	25—40 „	30 „
Rest	30—25 „	22 „
Total Period ...	120—130 „	101 „
Maximum rate of down movement of the tip of the leaflet.	about 1·2 mm. per second.	0·9 m.m. per second.

* *i.e.*, the tip moves away from ('up') and towards ('down') the base of the petiole.

† The figures actually given by Bose are only of total down movement and total up movement, since, as he points out, the movement does not actually cease.

The 'rest' at the upper and lower extremities of the path is probably only apparent, due to the slowing down of the movement below the rate at which it can be followed by the eye, as is the case in *Desmodium gyrans* (see previous foot-note.)* Nevertheless the beginning of the visible downward movement is so abrupt that it can be easily timed to about one second, and the commencement of the up movement is almost as sharply defined. The end of the movement is, in both cases, much less abrupt, and cannot be timed more exactly than to about four or five seconds.

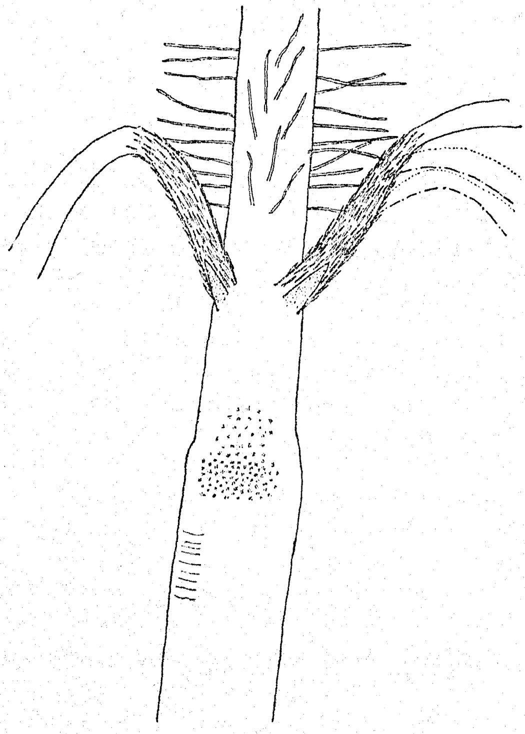


FIG. 2.

Fig. 2.—Petiolules and part of petiole of *Eleiotis sororia* DC., from a somewhat larger leaf, than that shown in Fig. 1. The dotted outlines and 'line and dot' outlines indicate successive positions drawn at intervals of a few seconds as the right leaflet moved down. Outlines traced with camera lucida × 15.

The upward journey is usually, but not always, slower than the downward; the latter takes place *below* the plane of the lamina (*i.e.*, below the plane of the drawing in figure 1) the upward journey *above* it, as indicated in the diagram on the right of the figure.

It is very seldom that the movement of the two leaflets is synchronous. The period may differ by any fraction of the whole, but the most common cases are:—(*a*) where one leaflet only lags a few seconds behind the other, and (*b*) where the lag is almost exactly half the total period, so that one leaflet is moving 'up' while the other is moving 'down'.

The movement may be almost uniformly smooth on both up and down journeys, but may, in other cases, be jerky in either direction,

but especially on the down part of the period. The movement naturally becomes more jerky if any obstacle is met with which temporarily stops the leaflet on its path.

The up and down movement of the leaflets is brought about mainly by a bending at the point of junction of the lamina with the very slender petiolule * (see figures 1 and 2), assisted to a small extent only by a slight curvature at the base of the petiolule. The latter part moves the petiolule through an arc of about 20°—30°, only, whereas the total movement is through an arc of about 140°. It is very curious that this should be so, as there is no visible pulvinus at the distal end of the petiolule. In this behaviour *Eleiotis* differs from *Desmodium*, in which, according to Bose (loc. cit.) the movement is brought about wholly by changes in turgidity of the pulvinus (at the proximal end of the petiolule), which is what one would naturally expect to find in both cases. Darwin, in his 'Power of movement in Plants' (1880), also states that it is on the length and degree of curvature of the pulvinus that the movement depends in *Desmodium.*

On August 18 a further series of observations was carried out from 1·0—1·45 p.m. on a transplanted specimen growing in a large flower-pot under the shade of a tree, at a temperature of 31° C. These observations confirmed those previously carried out, except that greater variability was found, both in the path followed by the tip of the leaflet, and in the time occupied by different phases of the movement and by the whole period. In regard to the first point it was noticed that some leaflets moved in such a way that the minor arc of the curve was not greatly less than the major. The quickest complete period observed was 78 seconds, the slowest 165 seconds, but the average of three periods in one leaflet and two periods in another was exactly 120 seconds, *i.e.*, almost precisely the same as the average previously observed. Observations made for me in December, 1921, in another part of North Gujarat, by Mr. B. R. Patel, on plants in their native habitat, also indicated an average period of just over two minutes, and some irregularity in the path of the tip of the leaflet.

I am indebted to the same observer for drawing my attention to another interesting point which had previously escaped my notice, namely that the leaflet rotates on its own axis synchronously with its other movements. During the *up* movement the lamina of the leaflet turns *outwards*, facing in the up position about 45° from the normal exposure. During the *down* movement the lamina turns *inwards*,

* The narrowest part, just below the lamina, is barely ·2 m.m. in diameter, the length being about 1·3 to 2·0 m.m.

reaching an exposure of about 45° inwards in the lowest position. Half way up or down it is approximately normal (*i.e.*, any line perpendicular to the plane of the lamina is in a plane perpendicular to the petiole.) The total rotation on their own axes is thus about 90°, whereas Darwin (loc. cit. p. 361) says that in *Desmodium gyrans* the leaflets "rotate on their own axes so that their upper surfaces are directed to all points of the compass". The various positions of the leaflets of *Eleiotis* is indicated at six points on the circumference of the ellipse in figure 1, p. 73.

It is perhaps worth pointing out that the curve described by the tip of the leaflet is a three-dimensional curve on the surface of a body closely approximating to the form of a sphere having its centre at the base of the leaflet. To describe such a curve as an "ellipse" or "oval" is obviously incorrect, since these are two-dimensional figures. Darwin and Bose (loc. cit.) however both fall into this error. The orthogonal projection of such a curve will, no doubt, be an ellipse, but this is not quite the same thing.

The curve in question is that indicated by the equation $Z^2 = \frac{X^2}{\tan^2 \alpha} + \frac{Y^2}{\tan^2 \beta}$ where α and β are the angles subtended at the centre of the sphere by half the major and minor axes respectively the radius of the sphere being taken as unity, and X. Y. Z. are the three ordinates of any point on the curve based on three planes of reference passing through the centre of the sphere. I am indebted to Mr. Ramswarup Sharma for kindly working out this equation for me. The equation assumes that the curve lies on the surface of a sphere of unit radius and that its orthogonal projection has the form of an ellipse.

On August 19 at 3-30 p.m., with light rain falling and a temperature of 26° C a few additional observations were made on a potted plant. A period was completed on this occasion in about 155 seconds. Particular attention was paid to the rotational oscillation on the petiole, *i.e*, the movement across the minor axis of the curve, and it was found that this component of the total movement was executed entirely at the base of the petiolule, though this takes only a very minor part in the longitudinal oscillation, and perhaps none in the rotational oscillation of the leaflet on its own axis. It is a particularly interesting fact that although the three components of the movement appear to be exactly synchronous (though they undoubtedly vary in relative amplitude) yet two of them originate almost wholly from the curvature and torsion of the distal end of the petiolule and the third entirely from curvature at its proximal end. In some leaflets there

appears to be a pulvinus at this point, but in others the whole petiolule is practically uniform. It is always densely hairy (see Figure 2) and it is possible that the whole petiolule should be ragarded as a pulvinus.

3. Summary

The autonomous movements of the lateral leaflets of *Eleiotis* are described. They have a longitudinal amplitude of about 140°. and an amplitude of rotation on the petiole of about 30°—100°, thus moving in a curve of which the orthogonal projection approximates to the form of an ellipse.

The frequency of vibration is such that a complete period is completed in about two minutes.

Synchronous with this movement is also a rotational oscillation of the leaflet on its own axis.

The movements are in many respects exceedingly similar to those of *Desmodium gyrans*, but differ in one interesting feature, namely that the movement along the major axis of the curve is chiefly brought about by the curvature of the distal end of the petiolule and only to a much smaller extent by the curvature of the proximal end (pulvinus ?)

In this respect the plant appears to be unique. No other case is known to the writer where comparatively rapid movements are brought about in pulvinate leaflets by any part other than the pulvinus. It seems clear, however, that the rotational oscillation of the leaflet round the petiole is brought about by curvature in the proximal end (pulvinus ?), though its rotation on its own axis can be traced to torsion in the distal part of the petiolule.

4. Literature cited

Bose. J. C., Researches on irritability in plants. 1913.

Cooke, T., Flora of the Bombay Presidency. 1903.

Darwin, C., The power of movement in plants. 1880.

MADHAVLAL RANCHHODLAL SCIENCE INSTITUTE.
AHMEDABAD.
August 19, 1922.

A CONTRIBUTION TO THE LIFE-HISTORY OF ANEURA INDICA *St.*

BY

SHIV RAM KASHYAP, B.A. M.SC., AND SHIVA KANT PANDE, B.SC.

(*Read before the meeting of the Indian Science Congress at Madras, 2nd February, 1922.*)

The genus *Aneura* is a very large one. Stephani describes 264 species in his Species hepaticarum (7). The genus is moreover very widely distributed in the whole world. *Aneura indica* is one of the few Indian species and was described by one of the writers of the present paper in the Journal of the Bombay Natural History Society (3). It is an extremely variable species in the shape and structure of the thallus and especially in the form of the upper epidermal cells. Although the life history of the genus is fairly well known from the investigations of some foreign species no Indian species has so far been investigated. In view of this fact and also on account of the extreme variability of *Aneura indica* it was thought likely that some interesting points might be found in this species and therefore the life history has been studied as far as possible.

The material was collected by Prof. Kashyap from various parts in the Western Himalayas during several years, and although the plants were preserved only in rectified spirit the preservation in many cases was exceptionally good, so that mitotic figures were clearly seen and the chromosomes could be counted more or less accurately in the thallus, the young antheridium, the seta and the young capsule. It may be stated as a result of these observations that there are twelve chromosomes in the sporophyte and six in the gametophyte. Clapp (2) has investigated *Aneura pinguis* very fully but she does not give the number of chromosomes in that species and so far as the writers know the number is not known in any other species of the genus also.

The capsule of *Aneura indica* has not been described up to this time. A very good spirit specimen kindly sent by Rai Bahadur K. Rangachari had a ripe capsule and the observations given here in that connection were made from that specimen. Our thanks are due to him for the material.

The thallus varies in thickness in the middle from eight cells (in plants occurring in the hills in moist and shady places) to

thirteen cells (in plants occurring in dry and exposed places in the plains). The epidermal cells are usually flat or slightly convex in moist and shady places whereas in dry and exposed places they are strongly papilliform. Here are some of the measurements in micrones :—(Pl. I-III.)

Locality	Cells of upper epidermis	Cells from middle of midrib	Cells of lower epidermis
Simla ...	32-37·8 by 32-33·6	72-84 by 64-75·6	32-33·6 by 32-37

Mussoorie, Dalhousie and South Indian specimens show similar charracters.

Chamba Valley ...	42 by 42	84 by 64	37·6 by 37·8
Sialkot ...	42 by 84	142·8 by 67·2	33·6 by 25·8

The Sialkot specimen was collected by the late L. Bishamber Das, M.Sc., of the Lahore Gevernment College. The great length of the epidermal cells in this specimen is due to their papillate form.

Rhizoids are smooth in all cases and do not present any peculiarities. They are variable in number in different specimens.

The plant is strictly dioecious. (Pl. IV) A brief description of the position of the male and female organs is given in the Journal of the Bombay Natural History Society mentioned above (3). We shall take here the development only. Although all stages in the development of the sex organs have not been seen, yet several were made out.

The Antheridium. The earliest stage seen consisted of a wall of seven cells in section, surrounding a single central cell. (Pl. V, Fig. 2.) A similar stage is figured by Campbell (1) with two cells in the centre. The whole was lying in a shallow pit and was not quite enclosed in the chamber. Later on the wall cells go on dividing by anticlinal walls only while the central cells gradually give rise to many cells by division in all directions. These cells are large and polygonal in shape and densly filled with protoplasm containing a very conspicuous nucleus with one or two nucleoli. (Pl. V, Fig. 3.) These cells give rise to the sperm mother cells after one or two divisions. The mother cells ultimately become rounded and the nucleus in them begins to be curved. (Pl. V, Fig. 6.) At this stage a small structure resembling a blepharoplast was seen in a few cases but it is doubtful whether it should really be called a blepharoplast. The nucleus goes on twisting spirally and the ripe sperm has two complete coils. (Pl. V, Figs. 7, 8.) The cilia could not be made out. Usually there is one antheridium in each cavity, but occasionally two antheridia were found in one. (Pl. V, Fig. 1.)

The archegonium. The earlier stages in the development of the archegonium were not observed satisfactorily. Pl. VI, Fig. 3,

shows that a single superficial cell has divided by two oblique walls and the resulting cell divided by a transverse wall. This is probably the young stage in the development of one of those scales or hairs which are found scattered among the archegonia at maturity. The youngest undoubted archegonium was quite well developed. There are 3–5 neck canal cells and 5 or 6 cells in each row of the neck. The central cell in the venter has the usual spherical shape and the ventral canal cell is cut off from it by a curved wall. (Pl. VI, Fig. 4.) The venter is two cells in thickness.

The sporogonium. The sporogonium remains inside the calyptra till a very late stage. As a matter of fact it is still enclosed by the calyptra when the spore mother cells are dividing. The spore mother cells become lobed during the division as is usual in the Jungermanniales. The chromosomes at this stage are short and stumpy and the cells are densely filled with granular cytoplasm. The elaters at this stage have a distinct nucleus, granular cytoplasm and a few vacuoles here and there, but as yet they possess no spiral bands. The capsule wall at this stage has become two layered except at the apex which is many cells thick. The apex is continued inwards and downwards to form the elaterophore to which the elaters are attached in a spreading manner (Pl. VII, Figs. 2, 3.) This elaterophore is an unusually long structure and extends to about the middle of the capsule. It is very much like a columella and reminds one of the conditions met with in some mosses like *Pottia* where the columella is very massive above but is not very firmly united to the base of the capsule.

The cells of the foot at this stage are large and granular and the cells of the thallus in contact with the foot are smaller than in other parts of the thallus. About this stage also the cells underlying the foot and a little away from it are slightly elongated in the direction of the long axis of the sporogonium, resembling the cells of the elaterophore, and are presumably concerned in the conduction of the food materials.

As stated above only one sporogonium was available for examination. In this the seta was 6 mm long, and the capsule was shortly cylindrical in shape and 2·5 mm in length. The wall of the capsule was two-layered except at the top as is usual in the genus. The walls of the cells of both the layers possessed thick and brown annular bands. The spores are lamellate with broad margins and each surface presents a wide polygonal area. The size varies from 20 to 30 μ. The elaters are about 190 μ long and have a single broad brown spiral as described by several observers in the genus, Stephani (7), Muller (5), Pearson (6), and Macvicar (4). Clapp (2), however,

found two spirals in some cases in *Aneura pinguis*. Two spirals have not been seen in the present species.

In transverse sections of the capsule there were indications that the capsule dehisced by four valves. It had not as yet actually dehisced.

General conclusions. The stages in the development of the sex organs so far seen are similar to those described by Campbell (1) and Clapp (2). The following are the special points worth mentioning.

1. The plant is very variable as regards the shape and thickness of the thallus and the shape and size of the upper epidermal cells.
2. The chromosomes are 6 in the gametophyte and 12 in the sporophyte.
3. The sporogonium, spores and elaters are described here for the first time.
4. The cells of the thallus underlying the foot are elongated, presumably for conduction.
5. The elaterophore is very highly developed, coming down to the middle of the capsule.
6. The wall of the capsule is two-layered and both layers possess broad brown annular bands on the walls of the cells.
7. The spores have a broad membranous margin and the elaters have a single spiral.

Literature cited

1. Campbell. D. H.—Mosses and Ferns. 1918.
2. Clapp, Grace L.—Life history of *Aneura pinguis*. Bot. Gaz. Vol. XIV, No 3. (Sep. 1912).
3. Kashyap, S. R.—Liverworts of the Western Himalayas and the Punjab. Jour. Bomb. Nat. History. Soc. Vol. XXV. No. 2.
4. Macvicar, S. M.—Handbook of British Hepaticae. 1912.
5. Muller, K.—Rabenhorst's Kryptogamen Flora. 1906-1911.
6. Pearson, W. H.—The Hepatics of the British Isles. 1902.
7. Stephani, F.—Species hepaticarum. 1900 and onwards.

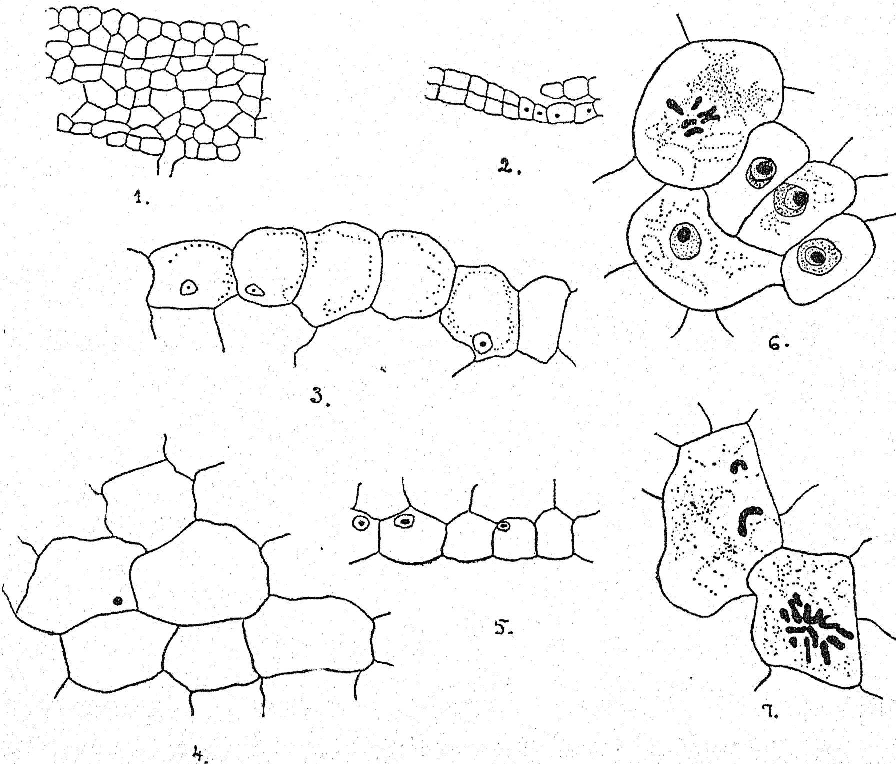


PLATE I.

PLATE I. Figs. 1—5 are those taken from the Simla specimen and the rest from the Chamba-Chuarie ones.

Fig. 1. Cross-section at the central part of the thallus × 65.

" 2. Wing × 65.

" 3. A few of the upper epidermal cells × 260.

" 4. A few of the central cells of the thallus × 260.

" 5. A few of the lower epidermal cells × 260.

" 6. A few cells from near the growing point × 700. (Note one cell with 6 chromosomes).

" 7. A few cells from near the growing point as in Fig. 6 × 700 (Note a cell with 12 chromosomes the double number produced before the division of the cell into two).

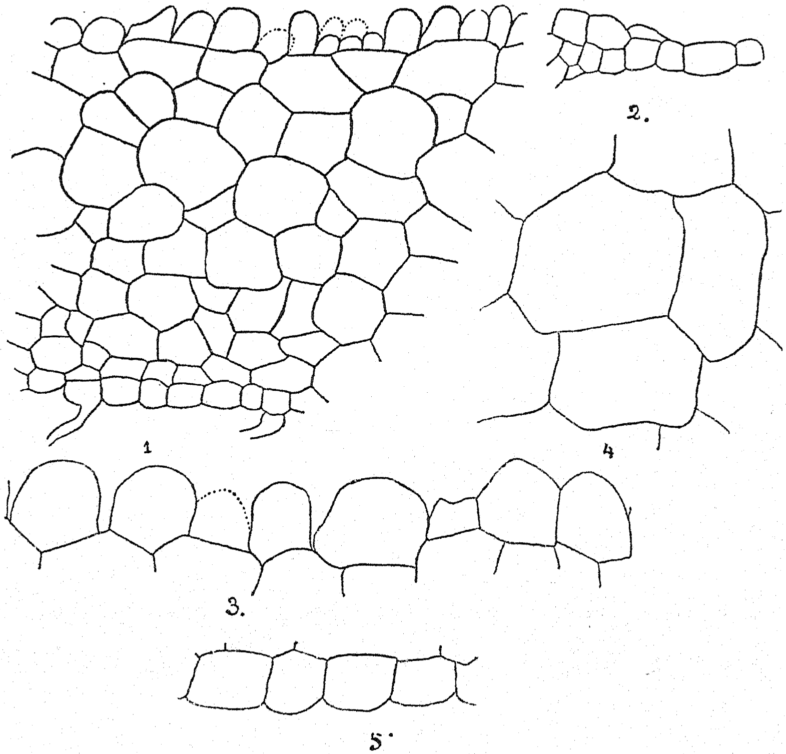


PLATE II.

PLATE II. All the Figs. are taken from Chamba Valley specimens.

Fig. 1. Cross-section at the central part of the thallus × 125.

„ 2. Wing × 125.

„ 3. A few of the upper epidermal cells × 250.

„ 4. A few of the central cells of the thallus × 250.

„ 5. A few of the lower epidermal cells × 250.

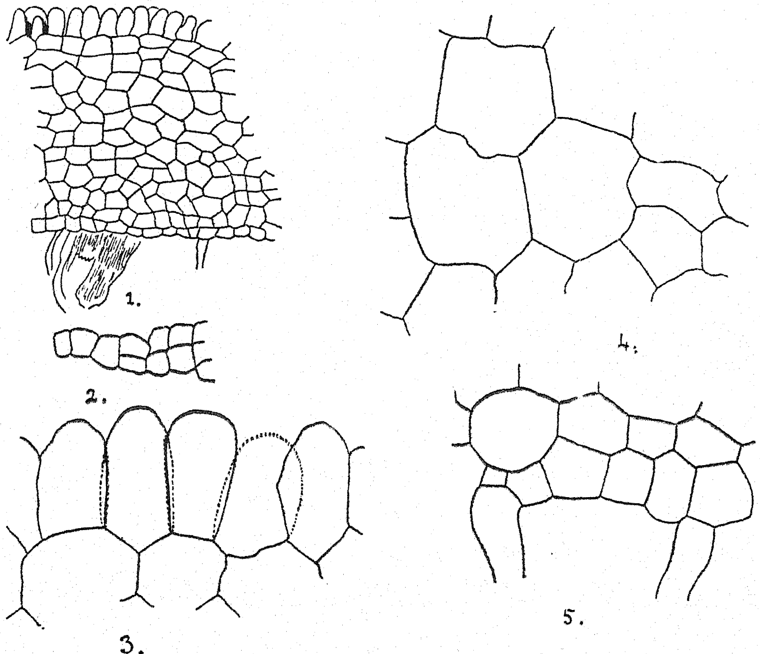


PLATE III.

PLATE III. All the figs. are taken from the Sialkot specimens.

Fig. 1. The cross-section at the central part of the thallus × 90.

,, 2. Wing × 60.

,, 3. A few of the upper epidermal cells × 180.

,, 4. A few of the central cells of the thallus. × 180.

,, 5. A few of the lower epidermal cells × 180.

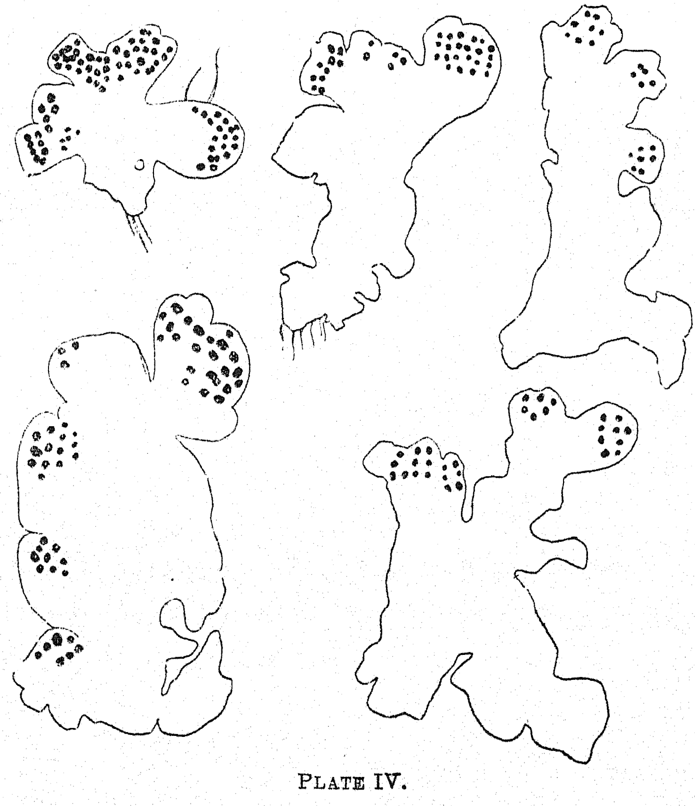


PLATE IV.

PLATE IV. All the Figs. are taken from the Chamba Chuarie specimens × 8.

A few of the male plants with antheridia on lateral branches.

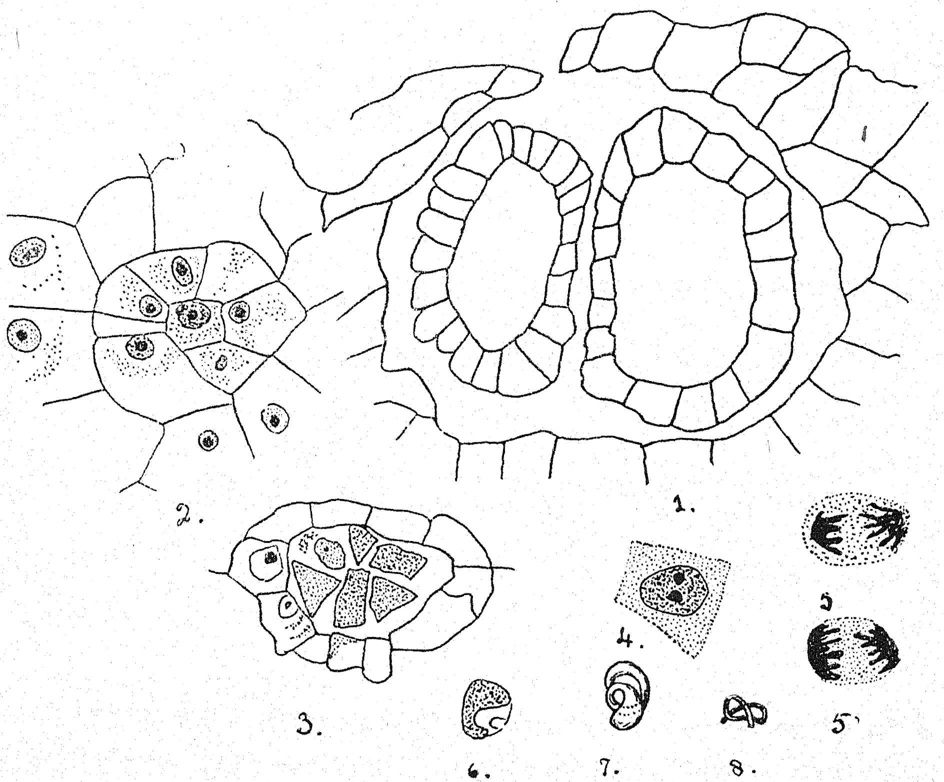


PLATE V.

PLATE V. All the figs. are taken from the Chamba Chuarie specimens.

Fig. 1. An antheridial chamber with two antheridia × 320.

,, 2. A young antheridium with one central cell and seven wall cells × 420.

,, 3. A later stage than 2 with several central cells and wall cells × 420.

,, 4. One of the central cells from fig. 3 × 1600.

,, 5 & 5′. Sperm mother cells dividing × 960.

,, 6. Sperm and a blepharoplast like structure × 960.

,, 7. A Sperm × 960.

,, 8. A sperm fully developed. × 960.

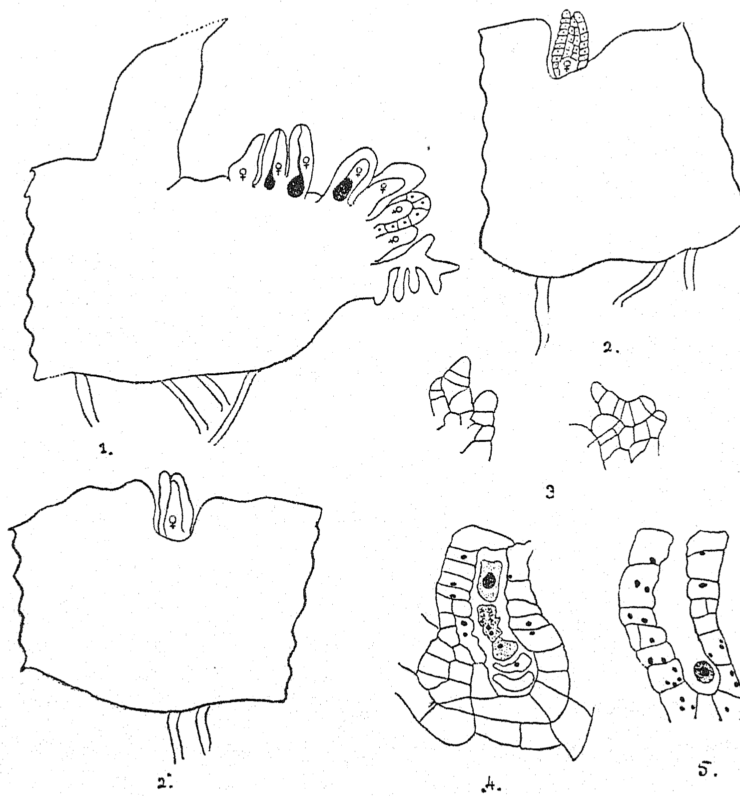


PLATE VI.

PLATE VI. Figs. 2 & 2' are taken from the Simla specimen, the rest from the Lahore ones.

Fig. 1. A number of archegonia in L.S.; borne on a lateral branch × 46.

" 2 & 2'. Sections through thalli each with an archegonium in a longitudinal section × 46.

" 3. Young stage in the development of a scale × 80.

" 4. A fully developed archegonium × 165.

" 5. An archegonium with a spherical egg after the disorganisation of the neck—and the ventral-canal cells × 165.

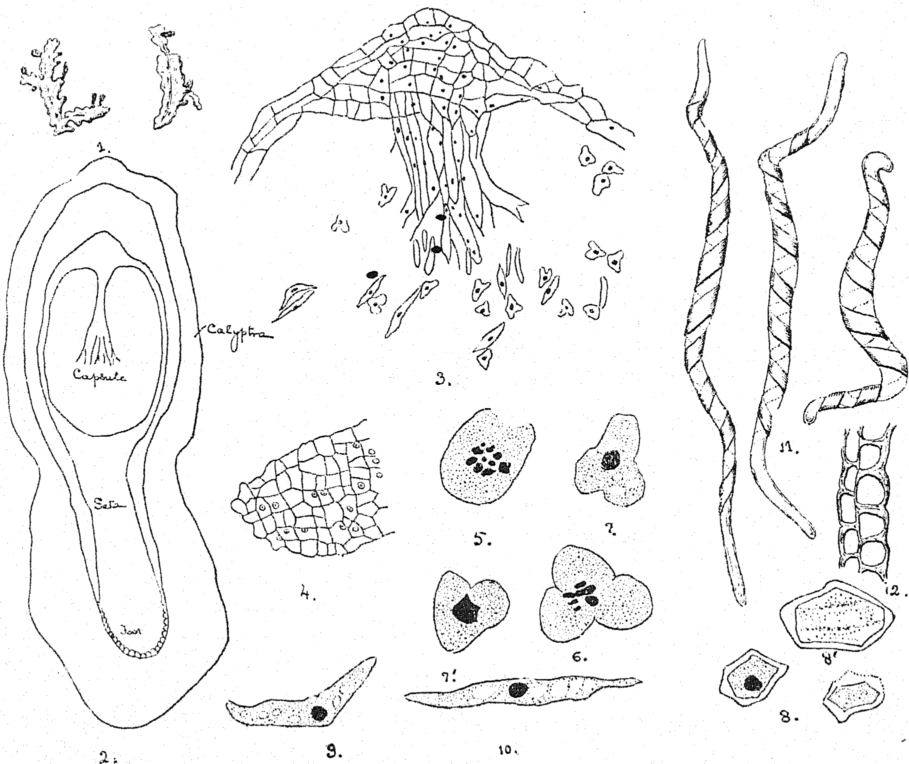


PLATE VII.

PLATE VII. All the figs. are taken from the Dalhousie specimens.

Fig. 1. A few plants with sporogonia 0.6.

,, 2. L.S. of a sporogonium yet within the calyptra × 35.

,, 3. Upper part of the capsule from fig. 2 × 87.

,, 4. Foot from fig. 2 × 87.

,, 5. Spore mother cells dividing × 750. (Note 12 chromosomes.)

,, 6. Spores in tetrad × 750. (Note 6 chromosomes)

,, 7 & 7′. Somewhat older spores in tetrads × 370.

,, 8 & 8′. Ripe spores × 640.

,, 9. Young elaters × 370.

,, 10. An elater at a somewhat later stage than in fig. 9 × 370.

,, 11. Old elaters × 390.

,, 12. Wall of the capsule × 240.

PRELIMINARY NOTE ON THE LIFE HISTORY OF *CEDRUS DEODARA* LOUD

BY W. T. SAXTON, F.L.S.

(Read before the Indian Science Congress, 1922.)

It is curious that up to the present no Botanist has published (so far as the writer is aware) any detailed account of the life history of Cedrus, though practically every other commonly accessible genus of Conifers has been carefully studied.

The writer was interested in the genus many years ago, but as rumours were heard of a *magnum opus* by a colonial Botanist no work was undertaken at that time. In 1915 a few collections were made in Mussoorie. These gave an approximate idea of dates for further work, but opportunity was lacking till the year 1921, when some additional material was collected from Murree during the hot weather. Since then a further large quantity of material has been very kindly made over to the writer by Dr. Winfield Dudgeon.

The results obtained so far indicate the following :—

1. Pollination occurs about the end of September, and fertilisation about the end of May, the interval of eight months being much less than in Pinus.
2. A considerable bulk of spongy tissue is formed as the ovule develops, but there are indications that its origin may not be quite the same as in Pinus.
3. The prothallus, at the time of fertilisation, is composed of exceedingly delicate tissue (more so than in Pinus at the corresponding stage), the number of archegonia being commonly three, less commonly six, or sometimes four or five.
4. The structure of the neck is very variable, but it is always composed of a considerable number of cells.
5. Actual fertilisation has not been seen as yet, but there are indications that some peculiarities may be met with here.
6. The development of the proembryo is almost precisely like that of Pinus, and the embryo is polycotyledonous.
7. The male gametophyte has not yet been studied.

MADHAVLAL RANCHHODLAL, SCIENCE INSTITUTE,
AHMEDABAD,
December 31, 1921.

THE INDIAN SPECIES OF ERIOCAULON

By P. F. Fyson, M.A., F.L.S.,
Presidency College, Madras.

(*Continued from Vol. III, p. 18.*)

Species of F.B.I. etc. reduced.

E. capellus-naiadis, *Hook. f.*	to E. setaccum, *L.*
E. caulescens, *Hook. f.*	to E. robustum, *Steud.* var caulescens.
E. subcaulescens, *Hook. f.*	to E. ceylanicum, *Koern.* following Hooker in Trimen's, "Flora of Ceylon."
E. policephalum, *Hook. f.*	to E. longicuspis, as a variety.
E. mitophyllum, *Hook. f.*	to E. miserum, *Koern.* as a variety.
E. Helferi, *Hook. f.*	to E. Wightianum, *Mart.*, as a variety.
E. Walkeri, *Hook. f.*	to E. quinquangulare, *Linn.*, as a variety.
E. Oliveri, *Fyson* E. Christopheri, *Fyson*	} to E. collinum, *Hook. f.*
E. Mariae, *Fyson*	to E. Thwaitesii, *Hook. f.*

Species reduced in F.B.I. now restored.

E. Hamiltonianum, *Mart*	from E. oryzetorum, *Mart.*
E. intermedum, *Koern*	from E. setaceum.

Species-name of F.B.I. changed, following Ruhland.

E. Dalzellii, *Koern.*	to E. rivulare, *Dalz.*
E. sericans, *Mart.*	to E. gracile, *Mart.*

Species new to F.B.I. and to Ruhland's monograph.

(Kew Bull. 1914)

E. Geoffreyi		
E. roseum	Vol. II,	p. 204
E. barba-caprae	,,	p. 197
E. Dianae	,,	p. 259
E. Rhodae	,,	p. 264
E. Margaretae	,,	p. 316
E. Elenorae	,,	p. 316
E. Thomasi	,,	p. 318
E. Horsley-kundae	Vol. III,	p. 13

1. Place. (Page 3, No. 1).

APPENDIX II

The Indian species of Eriocaulon in the principal Herbaria of India.

The following is a list of all the sheets of each species seen by me, arranged under the names of the various Herbaria as given above. In the first and second columns are given the collector's name and the number or other distinguishing mark of each sheet, with the locality as stated on the sheet; in the third column the name of the species as determined presumably in most cases by the collector, where, but only where, that differs from what I consider the true specific name. Of course in most cases the correction had already been made by others. It is hoped that this will prevent the mixing up again that sometimes occurs in herbaria, and also render it possible to collate duplicate sheets, if such exist, in herbaria outside India. Where more than one sheet of the collection is in the herbarium the number is added in brackets.

1. Eriocaulon setaceum Linn.

CALCUTTA		
Kurz 27-10-68	N. Bengal	......
do. 9/68	do.	......
C.P. 791	......	E. intermedium
Helfer, K.D., 5569, 5581	Tennaserim and Andamans	......
Griffith, K.D., 5569	E. Bengal	......
[Wall. Cat]. 6075	Gopalpore	E. Hamiltonianum
Brandis	......	Eriocaulon sp.
Stocks, Law, etc. [H. & T.]	Malabar and Concan	(1)
Collett 106	Nongkreen, Khasia	(3)
MADRAS		
......	Malabar, Eddicarrah, in tank	......
BOMBAY		
Talbot 633	Carwar	......
do. 1309 in part	do.	......
CEYLON		
W.F.	......	......
C.P. 791 in part	Pasdunhkorle, Dec. 1848 Gardner.	E. capillus-naidis H. f. (J.D.H.)
do.	......	do.
Trimen	Kewessee, Feb. 1886	do.
	Near Pelawatta 1887	do.
DEHRA-DUN		
Talbot 1309	Carwar N. Kanara	......

2. E. Eriocaulon Intermedium Koern.

CALCUTTA		
Wight 2857	......	......
J. D. H. & T. T.	Mt. Khasia	E. setaceum
Oldham	Khasia	......

CEYLON		
C.P. 791 in part	......	......

3. Eriocaulon Geoffreyi Fyson.

CALCUTTA		
1. Macoun	North Hastings 12-7-65	[2 merous.]
PRES. COLL., MADRAS		
Fyson 2085, 2165, 4463	Kodaikanal	(1, 2, 6)

4. Eriocaulon Colletti Hook. f.

CALCUTTA		
Candler	Upper Burmah, Shan Hills	......
Abdul Khalil	Southern Shan State, Laikaw	(2)
Lace 3139	Maymyo 3,500 ft.	......

5. Eriocaulon barba-caprae Fyson.

CALCUTTA		
Collett	Elephant Falls Shillong, 10-10-90.	......

6. Eriocaulon gregatum Koern.

CALCUTTA		
J. D. H. & T. T.	Mont. Khasia	(2)
Collett	Khasia Hills, Shillong	......
Clarke 18837	......	......
MADRAS		
J. D. H. & T. T.	Mont. Khasia	.....

7. Eriocaulon nepalense Prescott.

CALCUTTA		
Clarke 44827/A	Khasia	......
J. D. H. & T. T.	Mont. Khasia	(2) E. luzulaefolium
King	Sabbia Sikkim	......
Praim	Naga Hills	......
G. Mann	Khasia Hills	......
[Wall. Cat.] 6072 (inpart)	Nepal	E. quinquangulare
do. 6073/B	Tevoy	E. sexangulare
Kurz	......	......
R.E.P. 29693	Chitlong	E. alpestre
Smith, W. W.	Sureil, Sikkim, 5,200 ft.	E. luzulaefolium
70907	Sikkim	do.
MADRAS		
J. D. H. & T. T.	Khasia	......
DEHRA-DUN		
Gamble 15118	Tehri Garhwal	......
Gammice 18734	Palanpur, Kangra Dist.	......

8. Eriocaulon Pumilio Hook. f.

DEHRA-DUN		
Duthie, J. F. 4473	British Garhwal	......

9. Eriocaulon truncatum Ham.

CALCUTTA		
Strachey and Winter-bottom	Hanalbagh; Kumaon	[species uncertain] (2)

[Wall. Cat.] 6076	Munger Hills	......
do. 6072/C.	Nepal	E. sexangulare
Wight 2368/G	......	......
Clarke 16745	Dhaka, 1st Jan. 1872	E. eurypeplon
Shaik Mohim 125	Kochin Hills, Pidunch	......
Kurz 2/78	Kamorta Nicobar Islands	......
do. 230	Towards Phoungyee Eng forests	(2)
Meebold 15032	Pagaye, Burma	E. luzulaefolium
do. 17246	Kamamiring, Burma	do.
King 1246	Singapore, Malay Peninsula	(3)
Kurz 2977	Singapore	......
	Jheels Nirvene Dist., Oct. 1847	......
H.N.R. 8304	Langkawi, Kedah	......
Griffith K.D. 5567	Burma and Malay Peninsula	......
	Burpanei plains, on rocks, Dec. 1852	......
Kurz 134	Buitenzorg	......
No. 559 (det. Lotsy)	do.	......
King	Malay Peninsula, Wellesley	......
Beccari 866	Sumatra	......
Abu Hussain 53	Ranganaty Hills	......
Flora of Singapore	Bukit Mandae	(2)
Lister, J. L., (1876)	Chittagong	E. luzulaefolium
Hooker and Thomson	do.	......
Debbarman, P. M., 41	Strammura, Tipperah [var. trisepala]	(3)
MADRAS		
S.I. Flora 12017	Karkal S. Canara	(2)
	Tada, 17th March 1901	......
BOMBAY		
Talbot	Ratnagiri District	......
CEYLON		
C.P. 790 in part	......	......
	Meddekanda, Babamgodu	......
	Kitol Galle, 4-3-82	......
ST. XAVIER COLLEGE		
Blatter 2765	High Wavy Mts., Madura	......

10. Eriocaulon Trimeni Hook. f.

CEYLON		
1 Trimen	Dambulla Rock 1881	(2 type sheets)

11. Eriocaulon Duthiei Hook. f.

CALCUTTA		
Duthie 8436	Bhimkund, Khandwa Dist. C.P.	......
DEHRA-DUN		
Duthie 8136	Bhimkund, Khandwa Dist. C.P.	......

12. Ericaulon xeranthemum Mart.

CALCUTTA		
[Wall Cat.] 6081	Napalia	......
do. 6081 A	Nepal	(2)

[Wall Cat.] 6081 B	Silhet	......
do. 6081 C	Tavoy	(2)
Stocks	Concan	(2)
J. H. D. & T. T.	Mt. Khasia	......
Kurz, 2639	Rangoon	......
do.	N. Bengal	......
MADRAS		
S. India Flora 9401	Kannoth, Malabar	......
do. 12005	Karkal, S. Canara	(2)
Lawson	1884 Cochin, Travancore	......
......	Cochin, 30th July, 1887	......
J. D. H. & T. T.	Mt. Khasia	......

13. Eriocaulon luzulaefolium Mart.

CALCUTTA		
Wall. Cat. 6071	Assam Silhet	(3)
do. 6072/A	......	E. 5-angulare
do. 6072/B	Bengal	......
Col. Jenkins	Assam	(2)
Griffith, K. D., 5566	E. Bengal	......
[Wall Cat.] 6069 (? 6209)	Nepal	E. oryzetorum
H.B.C.	......	......
J. Marten	Garo Hills, Assam	......
...... 20,10,86	Baynath	......
Clarke 15587/G	Khusia	......
......	Assam	......
Simons	do.	......
Shaik Mokim 125	Kachin Hills	......
DEHRA-DUN		
Jenkins	Assam	......
Guroochurn 1988	Sunderbuns, Sept. 1839	......
......	......	......

14. Eriocaulon Thwaitesii, Koern.

CALCUTTA		
C.P. 790	......	......
Meebold 1160 F.	Neaduwattam, Nilgiris	E. achiton, Koern
do. 12124	Kavally, Cochin	E. argenteum
Fischer No. 3055	Kodaikanal, Up. Pulnis	......
do. 1329, 1271, 1462	Coimbatore S. India	......
MADRAS		
......	Jubbulpore	E. truncatum
CEYLON		
C.P. 790	......	E. truncatum
PRES. COLL., MADRAS		
Fyson No. 1485	Pulneys	(2)
do. 2086	Kodai downs	E. Mariae
do. 4471	Kodaikanal	(2)
do. 4462	......	(4)
Sedgwick 4646	Mahableshwar	......

ST. XAVIER'S COLL.		
833, 2767, 2768	High Wavy Mts.	......
SEDGWICK & BELL		
Sedgwick 4646	Lingvala Mahabaleshwar	......

15. Eriocaulon achiton Koern.

CALCUTTA		
Griffith, K. D., 5576	East Bengal	......
A.D., W.& S.	......	......
Clarke 15728 A.&C.	Khasia	......
Talbot		......
BOMBAY		
Talbot 3273	Santavari	E. xeranthemum
do.	Belgaum	......
DEHRA-DUN		
Griffith, K. D., 5576	East Bengal	......
ST. XAVIER'S COLL.		
2763	Salsette	......
SEDGWICK & BELL		
Sedgwick 2890	N. Nagayati, N. Kanara	......

16. Eriocaulon quinquangulare L.

CALCUTTA		
Winterbottom, J.E., 6	Below Ahmra	......
Anderson	20th November, 1858	E. setaceum
Prain	Madhoban	(2)
do.	Giridih	(2)
Campbell, J.	Flora of Manbhun	......
do. 8254 G. Watt	do.	......
do. No. 53	do.	E. trilobum
Clarke 20012	Bengal Comilla	do.
Falconer K. D. 1190	......	......
Griffith, K. D., 5570	Bengal	......
......	Sombulpore	......
Gamble 8618	Hazaribagh, Chota Nagpur	......
Wood, J. J., 1027	......	......
Prain	Daunda	E. luzulaefolium
do.	Chota Nagpur	......
Duthie 9802, 9803, 9806	Chandra District	(1,2)
Gamble 21611, 13626	Ganjam District	......
Meebold 9902	Kumsi, Mysore	......
do. 8352	Aglatti, Mysore	......
Bourne 2192, 2168	Tada, Nellore District	......
D. Hooper and M. S. Ramasami No. 39436	Mundandurai	E. sexangulare
Fischer 2972 (?)	Upper Palanies S. India	E. Sieboldianum
Griffith, ex-herb Hookerianum	Serampore	......
6074 B Herb Heyne	......	E. argenteum Mart
Wight K. D. 2367, (6674 A. Wall)	......	(2) E. argenteum Mart

Griffith K. D. 5564	E. Bengal	......
H. f. & Thomson T.	Gangetic Plain	......
Clarke 7938	Decca	......
A. Hussain	Goghat, Hughli District	(2)
Kurz	W. Bengal	(2)
Milne No. 35	Purulia	(2) E. luzulaefolium
Clarke 20849 A	Nagpore	......
"Roxburgh" 6 A	......	E. setaceum
Rev. J. Campbell 85	Flora or Manbhum	E. luzulaefolium
Gill, N.	Bengal, Sonthal Perus	do.
Clarke 3435/A	Chota Nagpur Singhbum	......
Lace, J.H., No. 2530	Orissa, Puri District	......
Walsh, Dr.	Khoonda	......
Wight K.D., 2855	......	......
Stocks & Law	Malabar and Concan	......
Thwaites C. P. 792	Ceylon	E. sexangulare
do.	......	......
C. P. 3562	......	......
Clarks 20849 C.	Purulia	......
......	var. Walkeri.	......
Walker	[W. H. Hooker 1838]	E. Walkeri
	var. Martiana.	
Wall. Cat. 7279	......	E. Martianum
MADRAS		
......	Kambakum, April 1903	(2)
......	Nungambakam 1st Feb. 1900	(3)
......	Tada, 13th March 1901	......
Wight 2367, 6074 A	......	E. argenteum
Bentham H. T. 6074	......	E. oryzetorum Mart
Cameron No. 459	Bangalore.	(5)
do. 357, 539	do.	......
do. 80	do.	......
	Mysore	......
S. I. Flora 8939	Kumbakum, Hills Chingleput Dt.	......
	Madras, iii 1883	......
Barber 1215	Tickapalli to Linepada, Ganjam Dt.	(2)
S. I. Flora 11483	Vandalore, Chingleput Dt.	(3)
S. I. Flora 10012	Chandragiri, Feb. 1914	......
BOMBAY		
Talbot 2948	Kanara	......
CEYLON		
	Dolosbagie, April 1882	E. luzulaefolium
C.P. 792 and O.C. 931	Kurungalle, July 1847	......
C.P. 792.	......	......
......	Galagedera, Oct. 1882	......
......	Pinnawala Balangode, Sept. 1881	......

var. Walkeri.

C.P. 3562	......	E. Walkeri
DEHRA-DUN		
J. F. Duthie 7048	Bundlekhand	......
do. 9802	Chanda District, C. P.	(2)
do. 9803	Chanda District	(2)
do. 9806	do. Central Prov.	......
(?) 9805	......	......
......	Almore 30-10-54	......
No. 297	22nd August '46	......
A. Webb	Simla hills 1892	......
......	? Jabulpore	......
PRES. COLL., MADRAS		......
Fyson 2286	Madras	......
do. 3542	Tirthahalli	......
SEDGWICK & BELL		......
Sedgwick 4876	Nadi Sapa, N. Kanara	......

17. Eriocaulon roseum Fyson.

CALCUTTA		
Kurz 232	Pegu	......

18. Ericaulon trilobum Ham.

CALCUTTA		
Kurz 12, 66	W. Bengal	......
Kurz	Lower Bengal, 1867	......
Griffith K.D., 5585	East Bengal	......
Anderson	......	......
Clarke	Hayaribagh, April, 1884	......
Winterbottom, No. 5	Kumaon	......
do. No. 4	Kumaon	E. gracile
Kurz	Bengal	(2)
DEHRA-DUN		
Duthie, 3454	Kumaon	......
do. 4476	Gangetic plain	......
Brandis	1880	[Probably]
Gammie 18670	Dharmsala	......

19. Eriocaulon collinum Hook f.

CALCUTTA		
Prain	Coonoor, Nilgiris	......
Gamble 12720	Coonoor	......
Clarke, 10912	Nilgiris	......
Meebold 11753	Pykara, Nilgiris	E. trilobum
Fischer, 3325, 2922, 2971	......	E. trilobum
do. 3067	Upper Palanis	E. cristatum
do. 9071	Shollapathi	E. cristatum
do. 1420	Grassland at 5000	......
King	Ootacamund	......
do.	Pykara	

Wight K.D. 2856	......	E. trilobum
Rev. St. Munch 69	Kodaikanal Lake	E. cristatum
Fisher	Upper Palanis	E. cristatum
MADRAS		
C.P. 796	......	E. luzulaefolium
......	Ooty, April, 1883	E. sexangulare
(Wight ?)	Nilgiris	......
......	......	E. luzulaefolium
CEYLON		
C.P. 796	Rambodde 1850	(2) E. luzulaefolium
	Horton Plains	......
A.M.S.	Ambewala Rd. Side, 19-3-06	......
do.	High Forest, Maturata, 8-5-06	......
do.	N. Eliya lake, 9-4-06	......
do.	Path to Fort Macdonald, 25-4-06	......
J.M.S.	Horton Plains, 2-5-1911	(2)
W.F.	Abbotsford, Dumbula	......
DEHRA-DUN		
C.P. 796	......	(1, 2) E. luzulaefolium
MADRAS PRES. COLL.		
Fyson, 546, 27, 8	Kodaikanal	......
do. 2992,3,4,5	Kotagiri	......
do. 2695, 2695 *b*., 2720	Pykara	(4, 2)
do. 4007, 4131, 4292	Kodaikanal	(6, 2, 2)
do. 4470	......	......
do. 2084, 4155, 4107	Kodaikanal	(2, 1, 5)
do. 4460,1,2,3, 7	do.	(2)
ST. XAVIER'S COLL.		
129, 829, 831-2, 2766-7	High Wavy Mts.	......

20. Eriocaulon Dianae Fyson.

CALCUTTA		
	var. *a*.	
Talbot 3166	N. Kanara	(2) E. luzulaefolium
Do. 696	Yellapore N. Kanara	......
Ritchi 1241-3	Belgaum Rice fields	......
	var. *c*. parviflora	
Talbot 558	N. Kanara	......
	var. *f*. triloboides	
Herb. Stocks	......	E. trilobum
Meebold 8236	Shaklaspur, Mysore	do.
Do. 9102, 9103	Khandala	E. sexangular
Do. 10322	Golitattu, S. Kanara	E. odoratum
Fischer 1350	Bellagi, Coimbatore	E. Sieboldianum
	var. *g*. conica	
Meebold 8348	Aglatti, Mysore	E. sexangulare
9733, 10320	......	E. truncatum
Fischer	Mahendragiri 1904	E. sexangulare

MADRAS		
	var. *b.*	
......	Calicut x. 85	......
	var. *c.*	
......	Coorg	......
	var. *d.* Richardiana	
Barber 2446	Jahlsur S. Kanara	E. sexangulare
	var. *f.* triloboides	
Herb. Stocks	......	E. trilobum
S. I. Flora 11851	Taliparamba, Malabar	E. quinquangulare
......	Ex. Hort. Bot. Calcutta	......
	var. *g.* conica	
......	Goodalur 15-11-18	......
BOMBAY		
	var. *c.*	
Talbot	Panchgang	......
do. 3166	Kumberwada	(2)
do.	Oct. 20th, 1883	......
do. 696	Yellapore	(2) E. quinquangulare
do. 3218	......	do.
do.	Dec. 10th, 83	do.
Parampje	Thana, 31-10-07	(2) E. luzulæfolium
R. Yam	Satiwati, 21-9-03	......
do. 2110	Palgar, Thana	E. xeranthemum
do. 259	Bassein, Thana	......
Gammie 16643	Matheran	(4) E. luzulæfolium
do. 15422	Khandala	do.
	var. *c.* parviflora.	
R.S. 558	N. Kanara	E. xeranthemum
Talbot 558	do.	do.
	var. *d.* Richardiana	
Talbot	Matheran	......
	var. *e.*	
Garadi	Lonovla, 2-11-05	E. luzulæfolium
Gammie, 15903	Shakarpathar	E. trilobum
do.	Lonavla 12-11-04, 11-11-07	(2) do.
do. 16021	Nadsur-Pati	(3) do.
do.	......	......
Chibbec	Lonavla 4-10-07	......
do. 236	......	......
	var. *f.*	
Talbot	Supa 15-11-1883	E. quinquangulare
......	Castle Rock, Dec. 1890	......

PRES. COLL., MADRAS

	var. *a*.	
Fyson 3819 (type) 3839	Rudrasiri, Mysore	......
Sedgwick, 2978	Bidi, Belgaum Dist.	......
	var. *e*.	
do. 1867, 1883	Tada, Dharwar	......
Fyson 3839	Rudrasiri	......
	var. *f*.	
Sedgwick, 5048	N. Kanara	(3)
ST. XAVIER'S COLL.		
2779, 2780, 2788-90.	Salsette	......
SEDGWICK & BELL		
	var. *l*.	
Sedgwick 2978	Bidi, Belgaum	
	var. *e*.	
Sedgwick 1867	Tada, Dharwar	... ..
do. 1883	......	[Connects with var f.]

21. **E. Sedgwickii** Fyson.

CALCUTTA		
Sedgwick 4572	Mahabaleshwar	......
BOMBAY		
Talbot 3274	Santaveri	......
PRES. COLL., MADRAS		
Sedgwick 4572, 4648,	Mahabaleshwar	(2)
do. 4671, 4837, 4847	do.	(2)
SEDGWICK & BELL		
Sedgwick 4548, 4572, 4648	Mahabaleshwar	......
do. 4671, 4837, 4847	do.	......

22. **Eriocaulon Brownianum** Mart.

CALCUTTA		
Wallich 6066	Mt. Silhet	[Type sheets] (3)
J. J.	......	......
Griffith K. D. 5574	E. Bengal	......
G, Mann 1876	Khasia	(3)
Clarke 7196, 15581	do.	......
do. 19132/D, 44870/A	do.	......
......	Shillong	......
......	Khasia	......
J.D.H. & T.T.	Khasia	(2)
Jenkins	Guowhutty, June 1848	......
Burkhill & S. C. Banerjee 102	Khasia Hills, Shillong	......
Collett	Shillong Khasi	......
No. 294 G. Mann	Khasia, June 1876	......
A.D.W. & S. Griffith	Khasia	......

Simons	Assam	(2)
......	Pedro, Ceylon 14-4-1859	......
Watt 7150	Manipur	(3)
......	12-4-59	......
Russell 1838 (Herb. Benth)	Peninsular India. Ord.	......
	var nilagirensis	
Wight K.D. 2859	......	(2)
Meebold 11751	Pykara	......
Fischer 2923	Upper Palnis	(2)
Meebold 13519	Devicolam Travancore	E. nilagirense
King	Pykara	(3) do.
Gamble 12330	Wellington	......
N. Brekitt No. 1267	......	......
Walker C. P. 939	Ceylon	(2) E. Wallichianum
C. P. 378 (Thwaites)	do.	(2)
Thwaites	do.	E. Wallichianum
Burkhill and Banerji 114	Dumpep 6,300 ft.	......
do. 158	Cherrapanji 4,460 ft.	......
Sauliere 914	......	E. Wightianum
MADRAS		
J. D. H. & T. T.	Khasia	......
George Watt 7150	Manipur	......
	var nilagirensis	
Bourne 688	Pulneys	......
iii 1883	Adam's Peak, Ceylon	......
......	Ceylon	......
BOMBAY		
	var nilagirensis	
Dr. Cooke	Ceylon	E. Wallichianum
DEHRA-DUN		
	var nilagirensis	
J. S. Gamble 11964	Rallia Nilgiri Dt.	......
12330	Wellington 6,000 ft.	......
CEYLON		
C. P. 377	Adam's Peak	......
C. P. 378	......	(2, 3, 2) E. Wightianum
do. 3382	......	(2, 2)
......	Dumbanagala Hill	......
......	Knuckles 1881	......
A. M. S.	Sita Eliya 21-3-06	......
	March 1906	
J. C. W.	Horton Plains 26-1-06	......
J. M. S.	Horton Plains	(2)
PRES. COLL., MADRAS		
	var nilagirensis	
Fyson No. 2083, 4162	Kodaikanal	(3, 4)
do. 4110, 3331	do.	(3)
......	Ooty	......

ST. XAVIER'S COLL.		
Blatter 13	High Wavy Mts. Madura	......

23. Eriocaulon robusto-brownianum. Ruhl.

CALCUTTA		
Dalzell 1878	......	E. Wallichiana
Mr. Law	Canara Dharwar & Bellary Districts	Ameletia floribunda
Dr. Ritchi 1243	Belgaum	......
Meebold 9730	Chickenally, Mysore	E. Brownianum
do. 9734	......	E. Wightianum
Talbot 3217	......	do.
do. 771	......	do.
Ex. Herb. Wight	......	......
MADRAS		
......	Vitry, Feb. 90	......
......	Malabar (in swamps)	[Diseased specimen showing phyllody]
DEHRA-DUN		
Lowrie 133	Perambad Ghat	......
BOMBAY		
W. A. Talbot 3217	Carwar N. Kanara	......
......	Londa. Flora of Belgaum	......
PRES. COLL., MADRAS		
P. F. Fyson No. 3691	Kumbarahalli	......
do. 3832	Rudrasiri W. Mysore	(2)
do. 3663, 3664	Belur, Mysore	(2, 5)
do. 1654	Igoor	E. mysorense
Sedgwick 3395	Castle Rock, 1,800 ft.	(3)
SEDGWICK & BELL		
Sedgwick 3395	Castle Rock, W. Ghats	......

24. Eriocaulon gracile Mart. (E. sericans of F. B. I.)

CALCUTTA		
Tavoy W. G. 6082	Prome 1826	......
[Wall. Cat.] 6079	Prome 1826	......
Clarke 36953	Dulkajahai, Sikkim var Kurzii	E. cristatum
Kurz 2638	Burma Rangoon	......

25. Eriocaulon Rhodae Fyson.

CALCUTTA		
Gamble 15421	Wynaad	......
Meebold 8273	Aglatti Mysore	(2) E. Wightianum
MADRAS		
Stuart	Wynaad	E. Brownianum
PRES. COLL., MADRAS		
Fyson 3696	Mysore	(2)

26. Eriocaulon Wightianum Mart.

CALCUTTA		
Kurz 2637	Rangoon Lake	(3)
do. 229	Wachong	(3)
Shaik Mokim	Tavoy	......
Wight Herb " Prop."	......	......
Griffith K. D. 5571	......	......
Wall. Cat. 6067, 6067 A.	......	......
	var Helferi	
Helferi 5584	Andamans	......
Wall. Cat. 6078	Kelaben	(2)
Meebold 8165	Rangoon	......

27. Eriocaulon lanceolatum Miq.

CALCUTTA		
Stocks & Law	Malabar and Concan	......

28. Eriocaulon odoratum Dalz.

CALCUTTA		
Stocks & Law	Malabar and Concan	......
Meebold 9889	Tealyuppa, Mysore	......

29. Eriocaulon longicuspis, Hook. f.

	var polycephala Hook. f.	
CALCUTTA		
Duthie 10580, 10581	C.P. near Pachmarli	......
Meebold 9737	Santaveri Babab, S. India	E. quir quangulare
MADRAS		
	var polycephala	
......	Palghat	......
DEHRA-DUN		
	var polycephala	
......	Pachmarhi, C.P.	......
Duthie 10580, 10581	......	......
CEYLON	......	......
C.P. 789	Ranovoddi, Jan. 1847	
PRES. COLL., MADRAS		
	var polycephalum,	
Fyson 3361	Kumbarahalli, Mysore	(3)
ST. XAVIER'S COLL.		
2781	Chedeth swamp Madras Pres.	E. quinquangulare

30. Eriocaulon atratum Koern.

MADRAS		
	Adam's Peak, Ceylon	......
CEYLON		
C.P. 61 & O.C. 932	Galagama, Feb. 1846	......
......	Maskeliya, March 1883	......
A.M.S.	Adam's Peak, 16-5-06	......

31. Eriocaulon ceylanicaun Koern.

CALCUTTA		
	var subcaulescens	
C.P. 61, C.P. 61 Ceylon	......	......
......	Pedro, 14-4-59	......
CEYLON		
J.M.S.	Horton Plain, 25-5-11	(2)
J.C.W.	do. 4-5-06	
	var subcaulescens	
C.P. 61,	......	E. atratum Koern. (Enum)
A.M.S.	N. Eliya Lake, 9-4-1900	E. zeylanicum
MADRAS		
	var subcaulescens	
C.P. 61	......	E. atratum Koern. (Enum)
Ceylon (C.P. 61) in part	......	E. atratum

32 Eriocaulon robustum Steud

CALCUTTA		
Wight (1871)	Nilgiris	......
Fischer 2301	Attapadi Hills, S. Malabar	(2)
Clarke 11046, B.D., F.G. & H.	Nilgiris	(5)
King 1409 B.	do.	E. atratum var major
Hk. *f* & Thomson	do.	E. bracteosum
Gamble 11793	Coonoor	E. nilgirense
Wright, K. D. 2860	......	......
Brekett 1833	Wattekelly Hill	E. Brownianum Mart
do. 1409	Nilgiris	......
	var caulcescens	
C.P. 131	......	E. sp. atratum B. major
MADRAS		
Rangachariar	Pykara, May 1899	......
......	Koondahs (Nilgiris)	......
......	Ooty, May, 1883	......
......	Pykara Bridge May, 1883	......
Barber 2683	Pykara, Nilgiris	......
......	29 Dec. 1900	(2)
Bidie	Nilgiris, 1877	(2)
DEHRA-DUN		
Gamble 14539	Nilgiris	......
do. 11793	do.	......
	var caulescens	
C.P. 131	......	......
BOMBAY		
......	Nilgiris	E. Wallichianum
PRES. COLL., MADRAS		
Fyson 2561, 2694	Pykara, Nilgiris	(6)

33. Eriocaulon cristatum Mart.

CALCUTTA		
No. 196 [Wall. Cat.] 6072 B.	Lower Bengal 1815	E. 5-angulare
Simons	Assam	......
Mr. Oldham	Khasia Hills	......
J. D H. & T. T.	do.	......
Burkhill & Banerji 35207	Khasia 5—6,000 ft.	(2)
Clarke 43529	Shillong 5,000 ft.	......
	......	Eriocaulon 408
Griffith K.D. 5568, 5578	E. Bengal	(2)
MADRAS		
J. D. H.& T. T.	Mount Khasia	......

34. Eriocaulon oryzetorum Mart.

CALCUTTA		
Wallich 6069	......	(2)
Falconer K.D. 1191	......	......
Kurz	Burma, 27-12-70	(2)
Winterbottam No. 1	Kumaon, Himalaya	......
1216	Dhoor	......
Clarke 34062/C	Chota Nagpur	......

35. Eriocaulon Hamiltonianum Mart.

CALCUTTA		
[Wall Cat.] 6077	Tavoy	E. setaceum Linn
Masters	Assam	......
„ 1019	......	E. oryzetorum
	var b. minor	
Dr. Ritchie 1246	Kala nudli	......
G. King	Siliguri, Nov. 1878	(3)
do.	Dehra-Dun, 3rd Oct. 70	(2)
	var c. minima	
Meebold 9893	Castle Rock	(2)
DEHRA-DUN		
Masters	Assam	......
ST. XAVIER'S COLL.		
	var c. minima	
3257	Igatpuri	......

36. Eriocaulon Edwardii Fyson.

CALCUTTA		
Clarke 34327	Chota Nagpur	E. xeranthemum
Gamble 1875	Sikkim	......
DEHRA-DUN		
Soohna 1334	......	......

37. Eriocaulon Margaretae Fyson.

CALCUTTA		
Sedgwick 2979	Bidi	......

BOMBAY		
Gammie 15553	Castle Rock	E. minutum
Gammie 15748	Castle Rock	do
do.	Lonavla, 12-11-04	do
PRES. COLL., MADRAS		
Fyson 3839	Rudrasiri, Mysore	......
Sedgwick 2979	Bidi, Belgaum District	......
SEDGWICK & BELL		......
Sedgwick 2979	Bidi, Belgaum District	......

38. Eriocaulon Eleanorae, Fyson

CALCUTTA		
Sedgwick 4570	Mahableshwar	......
MADRAS		
......	Gudalur, 15th Nov. 88, 3,000 ft	......
PRES. COLL., MADRAS		
Sedgwick 4570, 4647	Mahabaleshwar	(2, 2)
ST. XAVIER'S COLL.		
2782	Manontoddy	......
2794	Khandala	......
SEDGWICK & BELL.		
Sedgwick 4570, 4647	Mahabaleshwar	......
do. 4296	Castle Rock, Kanara	......

39. Eriocaulon minutum Hook f.

CALCUTTA		
Kurz	N. Bengal, 1-10-68	......
Duthie 6715	Govt. Botanical Garden, Sharanpur	......
Meebold 9105	Khandala	E. sexangulare
DEHRA-DUN		......
Duthie 6715	Maunt Abu	......
ST. XAVIER'S COLL.		
1800, 2778, 2783, 2784, 2792	Maurt Abu	......

40. Eriocaulon stellulatum Koern

CALCUTTA		
Stocks & Law [H. & T.]	Malabar & Concan	......
do.	Malabar & Concan & Mt. Khasia	......
1242/3	......	E. Wallichianum
Talbot 1598	Dursingudda, N. Kanara	......
Meebold 9894	Castle Rock	......
BOMBAY		
Gammie 15615, 15635	Castle Rock	(2, 2)

PRES. COLL., MADRAS

Fyson No. 3544	Tirthahalli, Mysore	......
Sedgwick 3233, 4507, 4571	Anmode and Mahabaleshwar	(1, 3, 1)

ST. XAVIER'S COLL.

2771	Panchgani	......

SEDGWICK & BELL.

Sedgwick 4507, 4571	Mahabaleshwar	......

41. Eriocaulon echinulatum Mart.

CALCUTTA

[Wall. Cat.] 6082	Kelaben, 9th Oct., 1827	(2)

42. Eriocaulon cuspidatum Dalz.

CALCUTTA

Dalzell 138	Concan	......
Stocks & Law [H. & T.]	Malabar and Concan	......
Talbot 1083	Siddapore in Rice fields	E. luzulaefolium var bracteata
Talbot 639	Belaveri, N. Kanara	......

BOMBAY

Talbot 638, 639	N. Kanara	......

PRES. COLL., MADRAS

Fyson 3543	Tirthahalli, Mysore.	(3)

43. Eriocaulon sexangulare L.

CALCUTTA

Griffeth 218	......	E. Wallichianum
Wight 2364, [Wall. Cat]. 6068		do.
do. [Wall. Cat.] 6068-A	Travancore	(2) do.
do. K.D. 2558	......	......
Stocks & Law [H. & T.]	Malabar and Concan and Ceylon.	......
C.P. 220	......	E. Wallichianum
Lawson 125	Trivandrum	......
Talbot 3219	N. Kanara	(2)
Meebold 489/12582	Alleppi, Travancore	......
do. 479/12572	Cochin	E. Wallichianum
do. 347/12640	Quilon	......
J. Watson 209	......	......
......	Nilambur	E. Wallichianum
Griffith K. D. 5572	Burma and Malay Peninsula	......
Kurz 2/75	Komarto, Nicobar Ils.	E. longifolium
do.	Nicobar Islands	......
do.	Moulmein, Burma	......
do.	Arracan, Boranga	......
do.	Singapore	......
do. XII 63	do.	E. longifolium
do.	Southern Burma	......

Falconer	Tenasserim	......
do.	Moulmein	(2)
Derry 277	Malacca Bukit Labokes	(2)
H. N. R. 5882	Singapore	......
Kunstler 107	Malay Archipelago	(5)
9335	Penang	......
J. D. Hooker	Malacca	......
Mr. Harvey	do.	......
Griffith	do.	......
Herb. Benth, 2328		E. Wallichianum
Kelsall	Malay Peninsula	......
do. 4097	Sungee, Jahore	(2)
King	Singapore	(2)
Wight 2364	......	......
......	S. India	E. Wallichianum
Griffith	......	(2)
Flora of Malacca 443	......	......
Shaik Mohin No. 74	Tavoy	(5) [two sheets of this No. different]
Flora of Malacca	Ayes, Panas	(2) E. Wallichianum
do. 227	Bukit Sabukor	E. Wallichii
do. 443	......	E. longifolium
Flora of Singapore	Jurong, 15th Oct., 1889	......
do.	Churchea Kang, 21-12-89 Dec. 21st 1889	E. Wallichii
do. 782	Perak	E. Wallichianum ?
do. 263	Sarawak, Borneo	E. quinquangulare
MADRAS		
......	Quilon, 8-12-1893	......
......	Swamps, Nilambur, 18. xi. 88	......
S. I. Flora 11970	S. Canara Dist.	(2)
C. A. Barber 2446	do.	......
......	Calicut, x. 85	......
125	Trivandrum, 14. x. 1893	......
BOMBAY		
Talbot	Yellapore	(3) E. wallichianum
do. 1327	Carwar	E. Wightianum ?
do. 3168	Kumberwada	(2)
do. 3219	Supa	......
Chibber	Londa	(2)
......	Islur, Kanara	E. capillus-naiadis
CEYLON		
C.P. 220	......	(2) E. wallichianum
W.F. March 1883,	Cinnamon Gardens	E. Wallichianum
......	Hunugawatte, June, 1895	......
DEHRA-DUN		
Talbot 1327	N. Kanara	......
do. 3219	do.	......

Lawson 125	Quilon	(2)
Anderson 189	Singapore	......
Brandis 2482	Ceylon	......
Falconer	Moulmein	......
PRES. COLL., MADRAS		
Fyson 3689	Kumbarahalli, Mysore	(5)
Sedgwick 5012, 5046	Sunkal, N. Kanara	......

44. Eriocaulon Thomasi Fyson.

CALCUTTA		
Meebold 9104	Khandala	E. luzulaefolium
do. 9899	Castle Rock	do.
Talbot	Jauner, August 1890	......
Stocks & Law [H. & T.]	Malabar & Concan	......
BOMBAY		
Chibber	Bassein, Thana	E. Wightianum
do. 12	Leonavla	do.
203	......	(2) do.
PRES. COLL., MADRAS		
Fyson 3542	Tirthahalli	......
Sedgwick 4340	Castle Rock	(2)
do. 3232	Anmode	......
ST. XAVIER'S COLL.		
2763	Salsette	......
SEDGWICK & BELL		
Bell 4340	Castle Rock, W. Ghats	......

45. Eriocaulon alpestre H. f. and T.

CALCUTTA		
J. D. H. & T. T.	Khasia	......
King	Ching-goo, Sikkim	(3)
do. 46	Kingloo Chumbi	(3)
Duthie 3454	Rainganga Valley, 3-4,000 ft.	......
Ribu and Rhomoo 4542	Chammago, Sikkim, 13,000 ft.	......
do.	Lachen, 8,000 ft.	......
Clarke 9567	Yalka, Sikkim	......
do. 45510	Nunknlow, Khasia	......
do. 18801	Sohra and Khasia, 5,000 ft.	E. Wallichianum
Hooker and Thomson	Sikkim and Khasia 8-12,000 ft., 5-6,000 ft.	
MADRAS		
J. D. H. & T. T.	Sikkim	......

46. Ericaulon horsley-kundae Fyson.

CALCUTTA		
Gamble 20985	Cuddappah Dist.	(3)
Talbot 1837	N. Canara	(2)

var magalocephela.

Talbot 2998	Kadur Mysore	E. trilobum
do. 3274	Babuden Hills Mysore	(2)
Meebold 11675	Naduvattam, Nilgiris	E. quinquangulare
do. 9731	Kulhutty Bababood	do.
do. 9732, 9735	do.	E. cristatum.
do. 11316	Badami	E. trilobum
Fischer 286-7	Anaibetta, Coimbatore Dist.	......

DEHRA-DUN

Gamble 20985	Cuddappah Dist.	

var megalocephela.

		......
J. Marten	Mandla Dist. C. Prov.	(2)

PRES. COLL., MADRAS

Fyson, O. S. 20	Snowden, Nilgiris	......
Sedgwick 4681	Panchgani 4,500 ft.	(2)

SEDGWICK & BELL

Sedgwick 4681	Table Land, Panchgani 4,500 ft.	......

47. **Eriocaulon breviscapum**, Koern.

CALCUTTA

Talbot 1609, 1379	Tinai	(3, 1)

BOMBAY

W. A. Talbot 2897	Anmode 2,000 ft., N. Kanara	......
do. 1379-1609	Tinai Ghat	E. Dalzelli
do. 1609	do.	(3)
do 3216	N. Kanara	......

PRES. COLL., MADRAS

Sedgwick 3321	Anmode, Kanara, 2,000 ft.	(2)

SEDGWICK & BELL

Sedgwick No. 3321	Anmode, Kanara 2,000 ft.	......

48. **Eriocaulon rivulare** Dalz.

CALCUTTA

N. Dalzell	1878	......
......	Muku hills, Jan. 1848	......
Hooker and Thomson	Malabar Concan, etc.	E. Dalzelli 1

BOMBAY

Talbot 167	Castle Rock	......
do.	......	E. Dalzelli 1
Chibber	Islur, Kanara	(2) E. capillus-naiadis

PRES. COLL., MADRAS

Sedgwick 3201	Anmode, W. Kanara	(4)

49. **Eriocaulon miserum** Koern.

CALCUTTA

Wall Cat 6070	Jentya hills 1829	......
1835 ? Jenkins	Assam Dept. collection	......
Clarke 42963	Khasia 2,500 ft.	......
Kurz	Goalpara Assam	(2)

var. mitophyllum

Clarke 18270 B	Shampong, Jainte 4,000 ft.	E. achiton
do.	do.	E. mitophyllum
Jenkins	Assam	
......	Khasia No. 7	......
279	......	......

50. **Eriocaulon fluviatile** Trimen.

CALCUTTA

Ritchie 1247	Tineh Purleh	E. Dalzellii

CEYLON

C. P. 3057	......	(2) [no heads]
Ferguson	Labugama 1882	......
......	do. 1885	(2)
......	Linigala 1886	......

51. **Eriocaulon Sieboldianum** Sieb. et Zucc

CALCUTTA

Eastern Bengal

[Wall. Cat.] 6073, 6073-A, 6077	......	......
Falconer K. D. 1192	......	E. sexangulare
Griffith K D. 5565, 5583	East Bengal	do.
do. K.D. 5579, 5589	......	......
Kurz	N. Bengal, 28-10-68	......
Masters	Assam	......
Clarke 20989 B	Cheybasia	......
do. 34492	Baraset	......
603/ K	In ricefields, K. Vally	......
	Chaniadro, Nov. 13, 1882	......
......	......	Eriophorum truncatum
......	......	E. hexangulare
Mann	Goalpara Dist. Assam 1886.	(2)
Prain	Shillong, Assam	......
King	Silliguree, Nov. 1878	[in part]
......	2 Khasia	E. trilobum
Jenkins	Assam	......
Clarke 7938	Parlash Dacca	......

Burma

Leg. Kurz 10/69	Arracan, Kolodyne valley.	......

Kashmir and Himalayas

Dr. J. L. Stewart	Kashmer	......

Winterbottom 3	Hanalbagah Kumaon	E. sexangulare
C. Pro., East Peninsular and Ceylon		
Stocks & Law. H. & T.	[mixed]	E. sexangulare
Duthie 9807	Chandra Dist., C. Prov.	......
Talbot 3173	N. Kanara	(2)
Meebold 759	Calicut	E. sexangulare
C. P. 795	......	E. sexangulare
[Wall Cat] 6077	......	......
MADRAS		
S. I. Flora 12017	Karkal, S. Canara	E. truncatum
do. 11576	Vandalur	(2) E. minutum
......	Cochin, 30-7-87	E. setaceum
J. D. H. and T. T.	Malabar and Concan	E. sexangulare
	Tada, 13 March 1901	......
BOMBAY		
Talbot 3173	Kumberwada	(2)
do. 1290	Carwar	(3)
do.	Kirwattee	......
Gammie	Lonavla	E. minutum
do. 15748	Castle Rock	(2) do.
Gamble 24994	Dehra-dun	......
CEYLON		
C. P. 795		
......	Mawarelle, 25th Feb. 1881	......
......	Balangoda, Sept. 1895	......
DEHRA-DUN		
Duthie 2584	Near Dehra	......
do. 9807	Chandra District	......
do. 9804	W. Jabbalpur	......
do. 7049	......	......
D. O. Witt 46 B.	Hoshangabad, C. P.	......
do. 46	Korai Range, C. P.	......
......	Sanharanpore Dist., 10-9-1846	......
......	Sanharanpore, 15-11-1846	......
Talbot 3173	N. Kanara	......
do. 1290	Karwar	......
Masters	Assam	......
185	......	Leucocephala graminifolia
Gamble 24994	Dehra Dun, Sept. 1894.	
SEDGWICK & BELL		
Bell No. 4243	Sulgri N. Kanara	......

I have to thank M.R.Ry. V. Narayanasawmi at Calcutta, Dr. Petch at Peradiniya, Mr. Hole at Dehra Dun, and Mr. Jacob at Coimbatore for very kindly reading and correcting the proofs of this list.

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Erratum

For horsley-kundae wherever it occurs in this work read horsley-kondae

CURRENT LITERATURE

Flower-Mechanism

Ashby, Edwin: Sensitive labellum in orchids. *The following account taken from the published minutes of a meeting of the Linnean Society on May 4th, may be of interest.*

"MR. EDWIN ASHBY exhibited pressed specimens of Orchids from South Australia including a number of the "spider-like" members of the genus *Caladenia*, and the green-hooded forms of the genus *Pterostylis*: many of these have a sensitive labellum which on the entrance of an insect closes up the entrance for a short period; Mr. Ashby suggested that this was for the purpose of fertilization. A member of the genus *Thelymitra*, which only open their bright-coloured petals in hot bright sunshiny days, and two species of *Caleya* were exhibited, both extremely local in that state, and both provided with a sensitive labellum, which, on being touched, folds up in two separate movements."

Algae

Turner Charles, F.C.S. The life-History of Staurastrum Dickiei var. parallelum (Nordst.). *The following has been published as an abstract by the Author of a paper read before the Linnean Society of London, 6th April, 1922.*

The want of rain, and the subsequent partial stagnation of the pools left by the side of a mountain stream in Denbighshire, was probably the cause of the very great number of zygospores produced by this desmid during the summer of 1921: fully one hundred of these were present on one microscope slide exhibited, in addition to the zygospores of two other species associated with them.

It was observed that the contents of the spores was, at first, of an oily character and that this circumstance rendered the early stages of the nucleus difficult to trace. During the later stages the production of four nuclei in the spore is readily visible, before its germination: this apparently indicates that the process of conjugation resulted in the formation of a diploid nucleus, and that a reduction division occurred inside the spore before the discharge of its contents. This early formation of "Desmid Mother-Cells" is frequently seen, and the germination of the spore results in the formation of four, three, two, or one desmid only, usually accompanied by an atrophied nucleus in the surrounding protoplasm when the smaller numbers are formed. The protoplasm is subsequently assimilated and the desmids go free.

The process of conjugation is usually of the normal type, and the zygospores are produced between the two desmids without the formation of a conjugation tube; but in one instance the occurrence of this rather uncommon condition was observed and a conjugation tube about 30 μ in length and 10 μ in diameter was seen. The conjugating desmids were asymmetrically

placed and the protoplasmic contents appeared to indicate a slight differentiation of the sexes, as it was passing from one to the other without a corresponding return. The conjugation of a four-rayed with a three-rayed form is not infrequent, and a four-rayed form may be occasionally seen associated with the three-rayed embryonic desmids in the protoplasm discharged from the same spore, when germination takes place.

The vegetative division is often accomplished by the development of a single circular bulging cell between the two semicells. The contents of this may divide, or an hour-glass constriction may cause the ultimate formation of two desmids.

Lloyd Williams. Life History of Laminaria and Chorda. *The following is taken from the published minutes of a meeting of the Linnean Society on 4th May, 1922.*

"PROF. J. LLOYD WILLIAMS, D.Sc., then gave an account of the Life-history of *Laminaria* and *Chorda*, illustrated with about 40 lantern-slides.

He remarked that up to a few years ago, Botany Students were taught that the Laminariaceæ, though they exhibit the highest advance in their external morphology and internal structure, possessed no method of sexual reproduction, but propagated themselves by means of asexual zoospores; and consequently they had to be classed, not with the higher, oogamous members of the Phæophyceæ, but with the lower Phæozoosporeæ. The recent discovery of the development from germinating zoospores of two kinds of gametophytes, producing respectively eggs and antherozoids, compels us to revise our ideas respecting the group and it systematic position.

The Author, after describing in detail the structure of the zoospore, its behaviour in germination, and the cytology of the processes, stated that cultures of *Laminaria* three weeks old, and of *Chorda*, three or four months old, almost invariably showed the presence of two kinds of multicellular germlings, one kind large-celled, the other consisting of cells many times smaller. Sauvageau, by observing the development in his culture of abnormal sporangia of *Saccorhiza,* was able to prove that both kinds of germlings were produced from zoospores in the same sporangium. All attempts at carrying the dicovery further by observing the actual liberation of the sexual cells failed until two years ago, when the Author witnessed the discharge of antherozoids and the process of fertilization. Lantern-slides were exhibited showing the two gametic nuclei within the eggs a little before fusion, and by comparison with the appearance of the sporophyte rudiment immediately after the first division of its fusion nucleus it was shown that the one condition can never be mistaken for the other.

The process of dehiscence of the oogonium and the liberation of the egg were explained in detail, and the difference beteen the behaviour of the inner wall in *Laminaria* and *Chorda* explained.

The Author had previously shown that Drew's supposed discovery of the sexual nature of the "Zoospores" was incorrect, but as some botanists still believe in it, additional evidence was adduced showing that the organisms described by him could not possibly have been the zoospores of *Laminaria* but must have been colourless monads. The Laminariaceæ thus show distinct alternation of generations: the plant is the sporophote; reduction of chromosomes takes place in the sporangium; there are two kinds of gametophytes

—a male and a female, and the difference in size between the generations is exceedingly great. The sporophyte may be gigantic, as compared with other algæ, whereas the gametophyte is microscopically small."

Fungi

Jackson, H. S. and **Mains. E. B.** Aecidial stage of the orange leaf rust of wheat, Puccinia triticina *Eriks. Jour. Ag. Res. 22 : 151–171. Pl. 1. 15th October, 1921.*

This is a common wheat rust the aecidial stage of which had been sought for years without success. The authors in view of its resemblance to other grass rusts having the aecidial stage on members of the Boraginaceæ or the Ranunculaceæ tried to grow its basidiospores on various members of these families they were successful on several species of Thalictrum. Different species of Thalictrum differ greatly in susceptibility, some being immune, some slightly susceptible and some very susceptible. They did not succeed in getting the rust to grow on any related genera. As P. triticina is confined to wheat, an introduced host, and as the most susceptible species of Thalictrum are exotic, they consider the rust to be of an origin foreign to America. (The abundance of this rust in India, with numerous Thalictrum species occurring in the hills raises the question as to the life history of the rust in this country.)

L. A. KENOYER.

Bacteria

Heller, Hilda Hempl. Phylogenetic position of bacteria. *Bot. Gaz. 72 : 390–396. 1921.*

The relationships of bacteria are by no means settled. Some following NAGELI and GÖTSCHLICH, emphasize the lack of chlorophyll, and regard bacteria as degenerate fungi. Others, following COHN, MIGULA, and SACHS, emphasize the morphological resemblance between bacteria and blue-green algae, and class them together as Schizophyta. A few have considered them as a quite independent group. Miss Heller argues against the 'degenerate fungi' view: "The trend of evolution is rarely in the direction of degeneracy. Degeneracy occurs as a consequence of a parasitic habit, or because of abundant food supply. It is usually accompanied by vestigial traces of former complexity. The characters which the bacteria and fungi have in common are not manifestly vestigial in the bacteria." Yet there are obvious features of resemblance to the fungi as well as to the Myxophyceae, and any satisfactory attempt to locate the bacteria phylogenetically must take *both* relationships into account. It has been found that certain bacteria are autotrophic, and the suggestion has been made that both blue-green algae and fungi, as well as the higher bacteria, may have been derived from these primitive autotrophic forms. The author accepts this position, and proposes to set the bacteria off in a separate phylum, co-ordinate with Myxophyceae and fungi. The name Bacteria is retained for this new phylum. The name has the advantage of being non-committal, and "will immediately be understood by the non-professional worker."

WINFIELD DUDGEON.

Cytology

Sharp, Lester W. An Introduction to Cytology. xiii+452 p. 159 figs. *McGraw-Hill Book Co. New York and London, 1921.*

"This book has been prepared for students of the biological sciences who desire a means of becoming more readily acquainted with the literature and problems of cytology." Nuclear division (the field of the author's most important contributions), chromosome reduction, and fertilization are described in considerable detail, and the cytological aspects of heredity occupy 5 chapters. The author has not attempted to arrive at dogmatic conclusions, and "in some chapters little more than catalogs of conflicting opinions" are given. The statements do, however, give a fair and accurate presentation of the present status of cytological thought and investigation. There is constant reference to the literature throughout the text, and a very full bibliography follows each chapter. Most of the diagrams and many of the figures are new, and the rest have been carefully redrawn from the original sources. The book is one that should be in the hands of everyone interested in cytology.

WINFIELD DUDGEON.

Microchemistry

Molish, Hans. Mikrochemie der Pflanze (Microchemistry of Plants). Second edition, 434 p., 135 figs. *Gustav Fischer : Jena, 1921.*

Microchemistry is playing an increasingly important part in the solution of biological problems, and every worker having to do with the details of plant structure and function ought to be able to avail himself of the aid that microchemistry can give. The present work is undoubtedly the best in any language on the subject. It takes up the scope, significance, and methods of microchemistry, and the occurrence and methods of identification of inorganic substances, alcohols, organic acids, fats, carbohydrates, aromatic compounds, pigments, alkaloids, proteins, enzymes, cell membranes, and other compounds and parts of the plant. Directions for carrying out the reactions are given in such simple language and in such detail that the average botanist should soon be able to work with confidence. The book is in no sense a mere compilation from the literature; the author has personally worked over most of the material, and satisfied himself of its value before including it in the book. The 135 figures illustrate unusually clearly the results of various reactions and tests. A very full bibliography follows each chapter. It is interesting that fully four-fifths of the references are in German.

WINFIELD DUDGEON.

Physiology

Paton, Julia Bayles. Pollen and pollen enzymes. *Amer. Jour. Bot. 8 : 471–501. 1921.*

Because of the meagre and conflicting information in the literature about the method of advance of the pollen tube through the tissues of the pistil, and because of the relation of pollen to hay fever and other forms of pollen poisoning, the author has undertaken a study of the enzyme content of various pollens. Ungerminated and germinated pollen grains of 18 species of plants belonging to 9 widely separated families were tested for 13 different enzymes. "Not every one of the 18 pollens was used in every test, but an effort was made to use as many as possible."

The conclusions are that "in most instances pollen tubes make their way between the walls of adjacent cells rather than penetrating them. We should expect therefore to find most frequently not a cytase—or cellulose-digesting enzyme, but rather a pectinase capable of digesting the pectin of the inner lamella. This has proved in the writer's experiments to be the case . . . . So far amylase, invertase, catalase, reductase, and pectinase have been found in all. Pepsin, trypsin, erepsin, and lipase have been demonstrated in some and not in others. Cytase was doubtfully identified in six of the eighteen. Tyrosinase and laccase have not been found in any, and zymase was found only in Siberian crab apple pollen."

WINFIELD DUDGEON.

Genetics

Schaffner, John H. Control of the sexual state in Arisæma triphyllum and Arisæma Dracontium. *Amer. Jour. Bot. 9: 72-78. 1922.*

During the last few years there has been a growing suspicion amongst botanists that the sporophytes of flowering plants are potentially bisexual; that even in those plants where the sexes appear to be completely segregated into separate individuals, one or the other sex is not eliminated, but its expression is merely suppressed. One fruitful line of experimental evidence is the "reversal" of sexual expression in a dioecious plant. The author has found *Arisaema triphyllum*, a dioecious aroid with a considerable percentage of bisporangiate individuals, to be specially favorable material for such studies. Examination of wild plants showed an average of 23 per cent. pure carpellate, 62 per cent. pure staminate, and 14 per cent. in some intermediate bisporangiate condition. There was, however, great variation from these percentages in different habitats. Plants of known sexual expression were then transplanted into conditions calculated to alter, or even reverse, the sex. The first year (1919) the soil was unfertilized and sparingly watered. The next year (1920) the young inflorescences were removed as soon as they appeared above ground, and the soil well watered and heavily manured. All plants made an extraordinary growth. The results of such treatment became evident the following season (1921). The results are shown in the table.

Original plants	Sexual expression 1919.	Sexual expression 1921.
9 staminate ...	9 staminate ...	8 carpellate. 1 intermediate
5 intermediate ..	5 staminate ...	4 carpellate. 1 staminate.
25 carpellate ...	21 Staminate ... 2 intermediate ... 2 carpellate ...	1 staminate. 1 intermediate. 22 carpellate. 1 did not bloom.

It will be seen that the sexual expression of these plants could be changed or even reversed at will, by altering the environmental conditions. *Arisaema dracontium* gave comparable results.

The author concludes that in *Arisaema*, sex "is a condition, and not

dependent on homozygous or heterozygous factors," and that "The factorial hypothesis cannot be entertained by botanists, and it is the writer's conviction that sex in the higher animals is no more determined by Mendelian factors than in plants, and that chromosome differences where they exist are merely indicators of sex and not determiners."

WINFIELD DUDGEON.

Natural History

Jivanna Rao P.S., Lessons in water plants *Journal of the Madras Agricultural Students Union Vol. X. (1922). 20 pp.*

This is an interesting little account of the larger water plants of the plains of South India, some 27 flowering plants Maisilea (2 sp.), Azolla, Chara and Spirogyra being very briefly described, with special Sreference to the habital, and structual, morphological or biolcgical peculiarities.

Trapa bispinosa we are sorry to see is described as getting rarer in this Presidency, as another species is in Europe, and special cultivation is recommended to prevent this, of Utricularia the author says that small aquatic animals are attracted by the secontions of the hairs on the bladders, and find their way into the bladder when it is hungry—ignoring Ekambaran's demonstration of the sucking in by the bladder on its trigger hairs being touched.

The author writes as one well acquainted with the plants he refers to, and the paper (of which reprints are available) is one to be commended to teachers of Botany in South India. P.F.F.

Palaeobotany

The following is taken from the published Minutes of the Linnean Society of London, for June 1st, 1922.

Professor A C. SEWARD, F.R.S., then delivered the third Hooker Lecture, entitled "A Study in Contrasts: The Past and Present Distribution of certain Ferns," illustrated by lantern-slides.

The Lecturer stated that a Botanist, especially one whose interest is not limited by the world of to-day feels certain kinship with the archæologist who seeks information on the life and nature of the people who fashioned and used the material discovered in the course of excavation. "For the Vegetable Kingdom also," as Asa Gray said, "there is a veritable archæology." The discovery of a deposit rich in fossil plants throws light interesting to the systematist or to the student of plant-geography, but our aim is to see in imagination the plants of other days as though they still lived, and the mechanism of the organism and something of the conditions under which they grew. The object of this lecture is to give examples of the application of palæobotanical enquiry to problems of plant-geography; to follow into the ages which man never knew, the history of some families of Ferns; to trace their wanderings and to discover their original home. The data gathered from existing plants must be supplemented by records of the rocks, records as Darwin said, of a history imperfectly kept, and of this chapter only here and there a few lines.

Once established, Ferns have a power of spreading by vegetative means, and the lightness and resistant nature of their spores enable them to play a successful role as colonisers and emigrants to new countries. When Treub

visited Krakatau three years after its violent volcanic eruption, he found eleven species of Ferns as pioneers of the new flora. As a class, Ferns are cosmopolitan, though certain of them are strictly limited in their range and highly sensitive to the influence of physical or climatic conditions; the Bracken, *Cystopteris fragilis* and *Pelystichum Lonchitis* were adduced as examples.

The following families were then passed in review: Gleicheniaceæ, Matonineæ, Dipteridineæ, Schizæaceæ, and Marattiaceæ; the Lecturer's object being to bring together some of the facts already published than to attempt to add much that is new. Palæozoic forms were excluded, partly because of the difficulty of precise statement on their affinity, but chiefly because it is not until the Mesozoic era that existing types became clearly defined. Twice only had he collected fronds of *Gleichenia*; on the edge of a Malayan forest where it luxuriated under a tropical climate, and from sediments deposited in a delta or inland lake on the submerged fringe of Cretaceous Greenland. The apparent identity of the living and the dead gives reality to Carpenter's aphorism: "We are still living in the Cretaceous period." In one of his letters, Hooker expresses the opinion that "Geology gives no evidence of a progression in plants," and adds: "I do not say that this is a proof of there *never* having been a progression—that is quite a different matter—but the fact that there is less structural difference between the recognisable representatives of Conifers, Cycadeæ, Lycopodiaceœe, etc, and Dicotyledons of the chalk and those of the present day, than between the animals of those periods and their living representative, appears to me a very remarkable fact." The unfolding of plant-life viewed through the distorting mists over the successive stages of earth-history, takes the form of a series of outburts of energy; the records of one period tell us nothing, while those of the next reveal a fresh type of vegetation, or it may be, a single genus in possession of widely-scattered regions of the world. We seem unable to do more than observe the completed results; the beginnings are hidden from us, and the farther we penetrate into the past the farther into the distance recedes the object of our search.

There was no intention to connect the Mesozoic records with the Palæozic; between the two there appears to be a wide gulf. The difficulty of making direct contact between the age of Pteridosperms and the succeeding age of Ferns, may be largely due to the difficulty of determining whether a Palæozoic fern-like friend should be classed as a Pteridosperm or a true Fern; but, on the other hand, the relationship between the two ages may not be so close as it is usual to assume. In the latter part of the Triassic period, we seem to pass with remarkable suddenness to a new phase of plant evolution; the old order gives place to the new; one cycle is completed and another has begun. This transformation in the plant world may be intimately associated with some far-reaching event in the physical history of the earth's crust. It may well be that crustal foldings in the latter part of the Palæozoic era, and the prevalence of desert or semi-arid conditions over wide regions during a part of the Triassic period, were factors which influenced the progress and direction of plant development.

As continental areas shifted and land sea changed places it needs no geological knowledge to grasp the fact that the rocks accessible to investigation cannot give us all the clues we seek; parts of old continents remain; others are beyond our reach.

After the above had been set up in type the paper itself was received and the following extracts from this very important lecture may be of interest. (Jour. Linn. Soc. Lon. Botany XLVI, No. 307, October, 1922, pp. 219—240 and 4 maps.)

In reviewing the present and past distribution of certain the Gleicheniaceæ, Matonineæ and Dipteridinæ, Schizæaceæ, and Marattiaceæ, the lecturer showed that certain main facts or ideas emerge. These groups of ferns were born in the Mesozoic age, without any direct connection by descent with Palæozcic forms. " Between the Palæozoic forests and the sun cracked mud ......of the Triassic period......there is a difference which marks the parting of the ways............The revolution in the earth's crust......must have had its reflex in the organic world.......It is not merely missing chapters that give the impression of discontinuity in the history of life. The apparent sudden change in the general facies of the plant world is the expression of an almost catastropic adjustment to a new condition of stability in the crust of the earth. As new lands emerged from the sea, new lines of evolution may have been inaugurated; the transmigration of marine plants which......conceives as a single act, may have been recurrent." " It is conceivable that plant life viewed as a whole may best be represented by separate and independent lines of evolution......each being initiated by some revolution in the organic world." "In India and elsewhere of the ancient continent of Gondwana land, the geological succession is more gradual, but there is not sufficient reason, at least as yet, to warrant the assertion that this continent was the birthplace of ferns which in the early Mesozoic period spread from one end of the world to the other." Again the genera Matonia and Dipteris are instances of ancient widely spread sections of ferns now confined to small areas, and go to show that " among ferns at least vigirous development and rapid spread coincide with the earlier stages of their careers, whereas restricted......distribution are interpreted as evidence of declining vigour." In other words the geological history of ferns does not support Willis' Age and Area theory, as indeed is admitted for geological evidence in general in his book, and Dr. Willis from the first pointed out that his theory could be expected to hold only of fairly large masses of plants. Finally " whatever may have been the main trend of migration.........Gleichenia, Dipteris and Matonia are impressive examples of constancy in a changing world; in the course of their wanderings from one part of the world to another they have suffered but little change, since the days which preceded the mysterious rise to ascendancy of the flowering plants."

P.F.F.

Books

Fritsch F. E. and Salisbury E. J. Botany for students of Medicine and Pharmacy, pp. 346, Ill. 163. *London, G. Bell and Sons, 10/6 nett.*

This book has been written specially for the use of medical students. Prominence is therefore given all through to the physiological side: but morphology is by no means entirely suppressed, and in an introduction by Prof. Boycott of Liverpool, emphasis is laid on the necessity for the medical student of a training in a much wider field than that which may appear to be of use in medicine.

The book opens with a general account of the ordinary flowering plant, its form and mode of life, and a comparison is made with the animal. Then are passed in turn, the seed, root, and shoot. Chapters on structure and physiology, beginning with the cell and its contents, lead on in much the same way as is usual in text books, to phenomena of growth and movement, but with more stress on the products of metabolisim. Five chapters are devoted to flowerless plants, two to the reproductive organs, embryology, and the dispersion of the fully developed seed; then two to classification and evolution.

Though reference is made throughout to English plants, the book contains so much of general applicability, that it should be very useful for medical students in this country, more especially as our medical examinations follow closely the lines of those of Great Britain, and the ordinary small English text-book read by medical students out here is so poor in general physiology.

P.F.F.

K. Rangachariar, M,A., L.T. Manual of Elementary Botany for India, Lecturing Botanist Agricultural College, Coimbatore. Second edition, pp. 518—40 pp. appendices, 471 illustrations. *Madras Government Press. Four rupees.*

The first edition of this work appeared six years ago, and met with a ready welcome. In this edition a number of new facts and illustrations have been incorporated with a chapter on Mendelism and a supplemental one on Gymnosperms. The book now approximates to the ordinary botanical text-book, but specially adopted for South India, and the word elementary in its title is a misnomer. As a manual for students to refer to it will probably be found extremely useful. The author has been fortunate in having the large resources of the Agricultural Research Institute at his disposal, and the use of the excellent artists attached thereto to draw his figures, most of which leave nothing to be desired. But the photo on p. 428 does not do justice to the subject and might have been left out. The author is to be congratulated on a very useful production.

P.F.F.

K. Rangachariar and C. Tadulingam. A Handbook of South Indian Grasses. *Madras Government Press (1921) Rs. 4-8.*

My first impression on opening this book was one of admiration and wonder at the industry of the authors; and congratulation to future botanists of South India that they will have ready to hand so easy a guide to this somewhat difficult group of plants. Had such a book been available when I came out eighteen years ago it would have meant very much to me. There are in all about 180 figures of grass plants or their parts, and 47 of their structure. The book is convenient to hold and the printing is excellent. I am tempted to conclude this notice here and to leave it at that. But a reviewer is expected not merely to praise, but also to point out where perhaps improvements might be made, and the remarks which follow are offered in no carping spirit, but in the hope that they may be of help when a new edition is brought out.

Taking the illustrations first, some are excellent but quite a number seem to have been made from herbarium specimens, and do not show the plant as it grows. I doubt if any one would recognise from Fig. 162 the common spear grass *Heteropogon contortus*. Those gracefully bending spikes, ending in a slendar brush of long awns, are here miserably shown. Another maltreated plant is that of Fig. 99, here the long flowering stems are shown doubled back. A more naturalistic treatment would have been to show them as cut off and standing erect alongside, if to show the whole plant as it grows was considered to make the details too small. Similarly Fig. 82 and many others.

In the Introductory part, chapters II and III, the authors have fallen into the easy error of introducing too many technical terms, and insisting on meticulous accuracy which they do not themselves practise (and quite rightly so) in the later descriptive part. Thus we read on page 11 that we are to distinguish between a spike and a spiciform raceme, and that the inflorescence of *Panicum javanicum* is a compound raceme; but on page 86 it is described as a panicle of spikes, which indeed is a much better description.

Chapter IV of 24 pages, on the structure of the haulm and leaves, is an interesting addition and shows meritorious investigation; but since no reference is made of structure in the descriptive and analytical part of the book, seems out of place here. Moreover it contains figures from grasses which are not included in the main body of the work. The chapter indeed gives us rather the impression of an undigested mass of facts, which just miss being of value because not classified. Except for a remark on page 38 that sclerenchyma is generally very considerable in dry situations, there is no correlation brought out between structure and function; and, while motor cells are mentioned on page 38 and shown in several figures, their use is left to th- imagination.

The descriptions may be relied on as botanically accurate, but as aids to the identification of the plants as they grow are weak, since they lack all reference to outstanding characteristics. No mention is made for instance of the very flat horizontal habit of *Perotis latifoliä* when growing on sand, its most characteristic habitat; nor of the spiny leaves of *Spinifex*, the beautiful silver panicles of *Saccharum spontaneum*, and the gloriously red steams of *Ischaemum ciliare*, unless indeed the authors have identified the purple grass of the hills as not this last species, in which case so common and conspicuous a grass should certainly have been included.

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SOME OBSERVATIONS AND SUGGESTIONS REGARDING "NYCTINASTY".

BY

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I. Introduction.

The sleep movements of plants were known to the ancients, having been first noted, according to Pfeffer (10), by Pliny. According to the same author Linnæus was the first to draw attention to the common occurrence of such movements.

Later authors from De Candolle (4) to Hofmeister (8) appear to have held the view that such movements were due to a hereditary periodicity. Pfeffer (10) first showed in 1875 that these theories were untenable and he considered that the movements were due to either photonastic or thermonastic responses or a combination of the two. He proved that while a daily periodicity does exist, yet it only persists for a few days at most under constant conditions, and is in no way hereditary.

Darwin (3) added many facts and figures a few years later, but his view that all daily movements are the result of circumnutation does not appear to be tenable, and has not been generally accepted.

The known facts were well summarised by Kerner (9) in 1895, since when no one else has, so far as the author is aware, given a fuller general account of these movements than was given by him.

Physiologists, some of whom have been mentioned above, have repeatedly endeavoured to explain the causes which determine the nature of such movements, but with little success.

The present paper suggests a fresh view point from which the subject may be regarded, and which the writer hopes may put the

matter in a new and more instructive perspective. The discussion is preceded by some observations on about thirty of the commonest Indian plants. As only a part of the literature dealing with the subject is available to the writer it is quite probable that some of the observations recorded may have been made before, besides those referred to below. All but one * of the plants observed grow abundantly within a few hundred yards of the Gujarat College, Ahmedabad, that one being the only common shrub of the Murree hills (Temperate N.W. Himalayas) which showed any marked sleep movements out of a considerable number examined by the writer in May, 1921.

II. Observations.

Kerner (9) describes only two types of sleep position, one in which the leaflets of a compound leaf fold *upwards* on the rachis, and the other in which they fold *downwards*. He figures, however, a third type, in which the petiolules twist through 90° so as to bring the adaxial surfaces of the leaflets facing distally (*i.e.* away from the base of the petiole) and these then fold lengthwise along the rachis with the abaxial surface outermost. Of this type there are two subtypes, one in which leaves on a stem are concerned, and the other leaflets on a rachis. There is little or no difference in appearance, but in the former case the sleep position is initiated by an *untwisting* of the petiole, in the latter by a *twisting* of the petiolule.

Figure 1 shows an example of the first sort. It is a drawing of a young plant of *Phyllanthus Niruri* Linn. in the sleep position made at 10 p.m. on July 20. The position is taken up about half an hour before sunset and continues without noticeable change till about half an hour after sunrise, the day position being reached again about one hour after sunrise.

This plant was investigated by Pfeffer (10), and Darwin (3), apparently quoting Pfeffer, describes the leaves as leaflets, says that they twist when taking up the sleep position and that the movement is like that of *Cassia*. None of these statements appears to be correct, as *Phyllanthus* possesses leaves, not leaflets, according to the generally accepted views on morphology, the sleep position is initiated by an untwisting of the petiole, and the position taken up is not at all like any of the species of *Cassia* investigated by Darwin except *Cassia mimosoides* and from several other references it is abundantly clear

* An account of the sleep movements of this plant (*Indigofera Gerardiana*) only was read at the joint meeting of the Indian Science Congress (Botany Section) and Indian Botanical Society at Madras in January, 1922.

that when he speaks of this genus he refers to *C. corymbosa* and *C. floribunda*, which are closely similar to two of the species described below.*

Some species of *Euphorbia* show the same type of sleep position, *e.g.* *E. hypericifolia* Linn. var. *parviflora* Hook. f., *E. prostrata* Ait., *E. pilulifera* Linn. (much less markedly, however) and doubtless others. One species of this genus (*E. Jacquinifolia*) is mentioned by Darwin (3), but in this case the leaves sink, so it is obviously of quite a different type to the species named above.

In each of the cases described, as already mentioned, the sleep movement begins by the *untwisting* of the petiole through 90°, and it is the reverse movement to take up the day position which involves twisting.

Of the second sub-type various Leguminosæ are examples, more especially perhaps of the tribe Mimoseae. Those I have noted include *Sesbania aculeata* Poir., *Aeschynomene indica* Linn., *Cæsalpinia pulcherrima* Swartz., *Cassia auriculata* Linn., *Cassia pumila* Lamk., *Tamarindus indica* Linn., *Mimosa pudica* Linn., and *Acacia arabica* Willd., of which *Tamarindus* and *Mimosa pudica* were described by Darwin, and the latter plant by many other observers, while Darwin also includes *Cassia mimosoides* and *Acacia Farnesiana* in the same category as well as a few plants belonging to other genera. More plants in the plains of Western India seem to conform to this type than to any other.

Of plants belonging to Kerner's type with leaflets folding upwards, with the abaxial surface outwards, there are a good many. This only differs from the preceding type in that no twisting of the petiolules takes place. For convenience, and since they show some differences in detail, they may conveniently be divided into three sub-types including plants with (1) multifoliolate, (2) trifoliolate and (3) unifoliolate (or simple) leaves.

The multifoliolate type studied is *Indigofera enneaphylla* Linn., one of the commonest plants in closely grazed grass-land round Ahmedabad. This presents certain points of interest in regard to the nature of its movements, which are of further interest in comparison with *Indigofera Gerardiana* Wall., to be described later.

I. enneaphylla is normally a completely protrate plant with branches radiating from the top of the tap-root. The leaves during the day lie flat on the ground as shown in figure 2, drawn from vertically above the plant. They are brought into this position not by the bending of the petioles or any reaction of the main pulvinus,

* See also Pfeffer (11).

but by the twisting* of the basal part of the leaf rachis as is easily seen from the position of the groove along the upper side of the rachis in figure 2. The movement to assume the sleep position indicated in figure 3 (drawn, like figure 2, from vertically above the plant) is therefore two-fold, consisting of an *untwisting* of the rachis into its normal position combined with a simultaneous folding of the leaflets upwards till they are almost face to face, the odd leaflet finally embracing the penultimate pair as is often the case in odd-pinnate

No other example of this sub-type has been noted at present, but doubtless others occur. Darwin (3) mentions *Indigofera* as a genus in which he had observed sleep movements, but gives no details.

Of the trifoliolate type *Crotalaria medicaginea* Lamk. VAR. *neglecta* Baker. is an example. The leaf, seen from above in figure 4. is palmately trifoliolate, and its day position is indicated in figure 5. In this case no complications are met with and the upward folding is symmetrical, the terminal leaflet outside the other two (figures 6 and 7) and all embracing the base of the leaf next above (not shown in the figures). Probably other examples occur; this one is abundant. Darwin figures two cases similar to this, *Medicago marina* and *Lotus Creticus*, but in both these cases there is no marked upward folding of the petiole such as is seen in *Crotalaria medicaginea*. The only species of *Crotalaria* he mentions, quoting observations of T. Thistleton Dyer, is a monophyllous species.

Alysicarpus vaginalis DC. illustrates the unifoliolate sub-type (figures 8 and 9). This species is also unusually sensitive to lateral illumination and to strong sunlight, but in dull weather the leaflet has an obliquely upward exposure, about 20°—30° to the horizontal, while the petiole slopes up about 60° to the horizontal. Thus the evening movement consists almost entirely of an upward bending of the petiolule until the leaflet is very exactly vertical. Neither *Alysicarpus monilifer* DC. nor *Alysicarpus hamosus* Edgew., both of which are equally common, show any appreciable movements.

Another example of the same type of movement is *Indigofera cordifolia* Heyne., and Darwin mentions a monophyllous *Crotalaria*.

Of Kerner's second type, with leaflets folding downwards, we may again distinguish plants with (1) multifoliolate, (2) trifoliolate and (3) simple leaves.

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* The writer cannot satisfy himself that there is more than a theoretical distinction between a "true torsion" and "curving along two intersecting planes." Moreover it would appear that curvatures in *three* planes (not two only) would be necessary to produce a result equivalent to a "true torsion." Cf. Schwendener (12) as quoted by Pfeffer (11) p. 104.

One of the multifoliolate sub-type is *Indigofera Gerardiana* Wall., the Himalayan shrub to which reference has already been made. This plant is a small shrub or undershrub, and is very abundant in Murree. It shows very conspicuous sleep movements, which were found to present some features of interest.

The observations recorded below were made on May 26 and June 1, 1921, in Murree, at an altitude of about 6,900 feet. Bright sunshine prevailed on the first date, but the locality was cut off from direct sunlight at about 6-15 p.m. by the shadow of a neighbouring hill. On the second occasion the sky was somewhat overcast about 6-0 p.m. when observations were begun and was fully overcast by 7-10. Sunset was observed at about 7-28. p.m. on May 26, by the same watch with which the remaining timings were taken.

The leaves of the plant are pinnate with 13 to 21 leaflets. The branches are very numerous and grow in almost any direction. The phyllotaxy is approximately $\frac{2}{5}$ but by bending (not twisting) of the petiole the arrangement becomes bifarious. The petiolules then bend across the rachis in such a way as to bring the laminae with their edges facing the stem, as shown in figure 10. Practically every leaf is arranged in this way, even on shoots growing vertically, and in this case the upper (adaxial) surfaces of all leaves on one shoot face towards the axis of the next higher order, as though the whole shoot were a bipinnate leaf.

It is not possible to understand the sleep movement without first explaining this rather remarkable day position of the leaves and leaflets.

As evening approaches, the upper leaflet of each pair, in vertical shoots, bends down, the movement taking place chiefly from the upper end of the petiolule, the lower leaflet remaining where it was before (compare figure 10 with figures 11 and 12). In very young leaves each leaflet also folds alongs its midrib, upwards, but in mature leaves the two leaflets remain almost flat and lie with their lower (abaxial) surfaces practically touching.

The folding is commonly symmetrical or nearly so (*vide* the lower leaf of figure 12), but varies from this to the upper leaflet of each pair folding almost along the rachis (*vide* figure 11 and the upper leaf of figure 12). The terminal leaflet also bends downwards, and usually also folds *upwards*, as shown in figures 11 and 12.

It is both curious and interesting to find so many points of difference between *Indigofera enneaphylla* and *I. Gerardiana*, one folding up, the other down, one assuming the day exposure on horizontal

branches by twisting of the rachis and the other by bending of the petiolules, etc. This shows that no general conclusions can be drawn about a genus from a study of one or two of its species, but that each case requires separate investigation.

Other plants with multifoliolate leaves, showing the downward folding arrangement, are the two almost equally abundant species of *Tephrosia*, *T. purpurea* Pers. and *T. villosa* Pers. The behaviour of the two is identical. In this case the leaflets of mature leaves simply fold face to face, without any complication, from a normal horizontal exposure. In younger leaves, as in *Indigofera Gerardiana*, the leaflets also fold, each along its own midrib, with the abaxial surface outwards. An extreme case is illustrated in figure 13 (from *T. villosa*) where the folded leaflets have actually overlapped and moved very considerably past the vertical position. All the leaflets of one leaf usually show this phenomenon to an equal degree.

Darwin (3) mentions *Tephrosia* in his list of genera showing sleep movements, but makes no further reference to it.

Indigofera hirsuta Linn. and *Cæsalpinia Bonducella* Fleming, are similar, but less regular, in their movements.

Of trifoliolate leaves with downward folding leaflets two have been noted, *Rhynchosia minima* DC., and a large leaved Leguminous plant, probably a form of *Phaseolus Mungo* Linn., growing as an escape from cultivation. Neither of these shows any special peculiarity, and no figures are given.

Sub-type 3 (simple leaves) is illustrated by *Abutilon indicum* Sweet., *Triumfetta rhomdoidea* Jacq., *Thespesia populnea* Soland, and *Achyranthes aspera* Linn., while, if we neglect the very small lateral leaflets, *Eleiotis sororia* DC. can alse be included here. In each case the leaf (or leaflet) hangs down vertically, or nearly so, at night. *Abutilon* and *Triumfetta* are mentioned by Darwin, but he gives no details except of one species of *Abutilon*.

The last case figured (*Cassia Tora* Linn., figure 14) looks like a perfectly straight-forward case of the downward folding type, but in point of fact is nothing of the sort, and does not agree with any of the types figured by Kerner (**9**), though Darwin (**3**, p. 370) gives an almost indentical drawing of *Cassia corymbosa*.

Cassia Tora is perhaps more exactly regular and symmetrical in its sleep movements than any other plant known to the writer. The leaves have normally a quite horizontal day exposure with the six leaflets very precisely in one plane. As evening approaches each leaflet begins to slowly revolve on its own midrib in such a direction

as to bring the adaxial surface facing outwards (away from the stem). This twisting continues through a little more than 180° and after the first 90°, have been passed through the leaflets also gradually and simultaneously fold together with their abaxial surfaces outwards. It might be expected that some special reason exists for this most remarkable movement, but no such reason is apparent; an examination of upper and lower epidermis shows them to be more or less alike, each having an approximately equal number of stomata. *Cassia occidentalis* Linn. shows precisely similar movements in some specimens, but less complete and less regular, while other specimens show practically no movements, although otherwise identical in appearance and apparent vigour. Darwin mentions three *Cassias* with very similar movements.

It seemed, at first, as if these movements were unique, but a connecting link was found, in *Cæsalpinia pulcherrima*, with the first type described in this paper. In this species most of the leaflets fold lengthwise along the rachis of the pinna, as already mentioned, but towards the tip of the pinna the leaflets twist though considerably more than 90°, so that they slope obliquely downwards, still with their adaxial faces in contact, and a little further twisting would bring them into the position of *Cassia Tora* leaflets.

A case different from any of the above is found in *Erythrina indica* Lamk. In this plant, unlike the five species of *Erythrina* observed by Darwin, the three leaflets neither rise nor fall but merely rotate, each on its own midrib, through 90°. Thus the terminal leaflet lies in the vertical plane in which the petiole is situated, while the laterals lie in a plane perpendicular to the first; the day position is approximately horizontal.

A few notes were made of the times of opening and closing, and of the length of time occupied in either process. These are very variable, even between two apparently identical specimens growing side by side, but still they afford a sufficient basis for one or two generalizations. In the following table the figures preceded by + or − signs denote minutes before (−) or after (+) sunset and sunrise respectively. In both cases the figure given refers to the time of *completing* the movement, and all figures are approximate.

Table.

Type.	Name of plant.	Time of closing.	Time of opening.	Time occupied in the movement.
1. A.	Phyllanthus Niruri *Linn.* ...	— 30	+ 50	40
	Euphorbia hypericifolia *Linn.* VAR. parviflora *Hook. f.* ...	0	+ 30	40
	Euphorbia prostrata *Ait.* ...	0 ?	+ 35	40
	Euphorbia pilulifera *Linn.* ...	Variable	...	...
1. B	Sesbania aculeata *Poir.* ...	— 10	+ 20	...
	Aeschynomene indica *Linn.* ...	— 15	...	...
	Cæsalpinia pulcherrima *Swarts.*	— ?	...	...
	Cassia auriculata *Linn.* ...	0	...	...
	Cassia pumila *Lamk.*	— 10	...	...
	Tamarindus indica *Linn.* ...	— 45	+ 15	...
	Mimosa pudica *Linn.*	...	+ 40	40
	Acacia arabica *Willd.*... ...	— 40	...	...
2. A.	Indigofera enneaphylla *Linn.* ...	— 10	+ 30	...
2. B.	Crotalaria medicaginea *Lamk.* VAR. neglecta *Baker.* ...	— 5	0 to + 10	40
2. C.	Alysicarpus vaginalis *DC.* ...	— 15	+ 25	...
	Indigofera cordifolia *Heyne.* ...	...	...	...
3. A.	Indigofera Gerardiana *Wall.* ...	—20 to —80	...	45
	Indigofera hirsuta *Linn.* ...	Variable	...	...
	Tephrosia purpurea *Pers.* ...	— 25	...	45
	Tephrosia villosa *Pers.* ...	— 25	...	45
	Cæsalpinia Bonducella *Fleming.*	+ 20	...	...
3. B.	Rhynchosia minima *DC.* ...	...	...	...
	? Phaseolus Mungo *Linn.* ...	+ ?	— ?	...

Table.—(*Contd.*)

Type.	Name of Plant.	Time of closing.	Time of opening.	Time occupied in the movement
3. C.	Abutilon indicum *Sweet.* ...	— 15	0	...
	Triumfetta rhomboidea *Jacq.* ...	— 15	— ?	...
	Thespesia populnea *Soland.* ...	...	...	...
	Eleiotis sororia *DC.*	— 10	...	...
	Achyranthes aspera *Linn* ...	— 10	— ?	...
Special Type.	Cassia Tora *Linn.*	— 20	+ 30	40
	Cassia occidentalis *Linn.* ...	Variable.	...	...
Special Type.	Erythrina indica *Lamk.* ...	— 10	...	...

The only conclusions one may draw from these very incomplete records is that both the folding and unfolding are in the large majority of cases carried out while the sun is up and that the time occupied in carrying out the closing movement is about 40 to 45 minutes. The opening movement occupies about the same time or slightly less.

III. Theoretical Discussion.

Various biological theories have been put forward to explain the sleep position of plants:— to reduce radiation into the cold night air,— to reduce transpiration by bringing the stomatal surfaces together,— to protect buds,— to prevent dew getting into the stomata,— inherited periodicity,— etc.

In the tropical summer, to picture a plant as requiring to reduce its radiation into the cold night air 30 to 60 minutes before sunset, requires a more vigorous imagination than the present writer can claim to possess. Even Darwin, who advocated this view for temperate countries, had obvious doubts whether it was applicable to the tropics. As the movements continue with unabated vigour even when both ground and air are almost fully saturated with water for days together, reduction of transpiration also seems inadequate as an explanation. Moreover it would appear that in many cases there is no correlation between the surface which is outermost and that

with the lesser number of stomata. The case of *Indigofera enneaphylla* (apart from other considerations) seems to preclude geotropism as the determining cause. The movements seem to occur neither more nor less vigorously when dew falls heavily than at other times, though such a difference would be expected if the movements have evolved as a means of keeping dew out of the stomata. Pfeffer showed nearly 50 years ago that the theory of hereditary periodicity was untenable.

It is difficult to see what other solution of the problem is possible if we assume that *the normal position of the plant is its day position* and that the night position is taken up under the influence of some stimulus which may be regarded as keeping the plant in a state of physiological strain. While no explicit statement may be found in some of the previous work on sleep movements that such an assumption is made, yet it appears reasonably clear that this is the case. Generations of physiologists have attempted to find a reason for the plant taking up its night position, while few seem to have been specially interested in the reverse movement.

But can we, on reflection, maintain that there is any logical justification for the assumption that the day position of the plant is its normal one? I believe we cannot. Doubtless the continuance of geotropic stimulus keeps the plant under some physiological strain at all times, but heliotropism imposes another set of strains during the day, from which the plant is relieved at night. Hence we should logically regard the *night* position of a plant as its normal position and that taken up during the day as a position of physiological strain. When the illumination falls much below the optimum (or rises much above it) the strain is relaxed and the plant reverts to its natural position.

The so-called "diurnal sleep" is really of the same nature as night sleep, as has been recognized by various authors. From the usual view point this has merely been an additional difficulty in the way of finding an explanation of sleep movements. From the writer's point of view, however, it is exactly what would be expected. Ewart (**5** and **6**) has clearly shown that the effects of strong sunlight, especially in the tropics, include the complete inhibition of photosynthesis in many cases. Cunningham (**2**) has given reasons for concluding that turgescence depends very largely on photosynthetic activity, and hence it may readily be seen that both at night and also under intense insolation conditions are set up which favour a relaxed state of the plant. The early hour when plants begin to show sleep movements in the afternoon is rather puzzling, on any theory, but

can perhaps be regarded as due to a condition of fatigue brought about by prolonged photosynthetic activity, and kept approximately constant under varying conditions of climate from day to day, by periodicity. Although periodicity has been proved to be neither permanent nor hereditary, it is nevertheless, as Pfeffer (**10**) has shown, a very real phenomenon.

Ewart (**6**) showed that the diurnal sleep movements could be brought about by strong illumination of the pulvinus in certain cases and that it was immaterial whether the pulvinus were illuminated from above or below; in either case the reaction is the same and the leaf places itself in the "paraheliotropic" position. He therefore applied the term "paraphotonastic" to such movements. It is difficult to explain these observations except on the theory that here also the plant simply passes into a normal state of relaxation from strain, due to the light being far more intense than the optimum for phototropic reactions.

That the "para—" position is so often the normal one, especially in the tropics, would be readily explained on the supposition, by no means improbable, that no mutant which possessed any other normal exposure would be able to survive the intense insolation of the tropics.

It is often noticeable that the 'sleep' position is similar to, or even identical with, the position of the leaflets or leaves in the bud. Pfeffer (**11**, p. 105) has already drawn attention to this fact, though, as he mentions also, there are exceptions. On the theory that the 'sleep' position is one of relaxation from strain this is at once seen to be perfectly natural.

We are so accustomed to think of the plants we see around us every day as being then in their natural positions, more especially as very many plants do not appreciably change their leaf positions at night, that it is only natural we should attempt to explain other positions as only taken up under some definite stimulus. Once the idea is visualized that the night position is not taken up as a special adaptation to anything whatever, but simply as a reversion to a normal state after the withdrawal, or lessening in intensity, of a stimulus, the difficulties cease to exist. The particular position which is normal to practically all plants showing sleep movements is, as we have seen, biologically adapted to protect the plant against intense isolation, and it is merely incidental that this position is also the sleep position. It seems likely that such a position may be of no advantage whatever to the plant at night.

As regards plants which have approximately the same position by night as by day it must be supposed that only by slow growth

changes do they take up the day position, and that if they revert at all during the night it is so little as not to be noticeable. Perhaps they do not possess the elasticity which enables other plants to so revert. In other cases it may be that the 'normal' position is that best suited to the daylight requirements of the plant. Such plants might, in general, be expected to be less sensitive to the effects of intense insolation.

It may fairly be said, therefore, if the view here advocated be accepted, that there is no such thing as "nyctinasty". If, then, we take the night position as the normal, can we speak of the assumption of the day position as "photonasty" or "helionasty"? I think as a general rule we can not; because the day position is usually taken up quite definitely *in relation to the direction* of incident light, as may be very readily observed in plants showing sleep movements. Hence neither the so-called "nyctinasty" nor its reverse can properly be regarded as "—nastic" reactions at all.

Pfeffer (**10** and **11**) maintains that many of the movements *are* photonastic, and he is supported by Ewart (**6**), but both these authors argue from the reverse point of view to that advocated here and the facts admit of another interpretation. Nevertheless the, writer does not wish to deny the possibility that some plants take up their day positions photonastically rather than as a phototropic reaction. Such cases, however, do not appear to be common.

It is perhaps unfortunate that so much attention has been focussed by many investigators on the sleep movements of *Mimosa pudica*. In some respects this plant is, as Haberlandt (**7**) has shown, unique in its physiological anatomy, and for this reason it is better to study it as a special problem, while it is hardly satisfactory to base wide generalizations on its behaviour.

Even in Darwin's time the plant had already been the subject of innumerable investigations, and Darwin (**3**) himself made various observations of the differential movements of the petiole, pinnae and pinnules. Cunningham (**2**) carried out various experiments with the plant and came to the conclusion that its movements differed only in degree and not in kind from those of various other plants showing sleep movements. He also strenuously opposed Haberlandt's view that the system of tubes associated with the phloem in *Mimosa* are concerned with the conduction of stimulus.

Many years later Sir J. C. Bose (**1**) carried out work on similar lines to that of Darwin but with much more elaborate apparatus, which enabled him to obtain automatic records of the various movements.

His results agree in the main with Darwin's investigations. Bose, however, seems to have been specially interested in the movements of the primary and secondary petioles, and to have paid little or no attention to the behaviour of the leaflets. He found, as Darwin had already shown, that the movement of the main petiole is reversed soon after sunset, and that an upward movement then continues for a large part of the night, and his remarks (**1**, p. 678) lead one to suppose that the whole of the changes from sleep position to-day position and *vice versa* are gradual, not only in the petiole of *Mimosa*, but in all "nyctinastic" reactions. There is no question of the correctness of the observations on the main petiole of *Mimosa*, but it is equally true that the folding and unfolding of the leaflets takes place in an exactly similar manner to many other plants of type 1.B. (see Table). Their sleep position is fully taken up by about sunset and no unfolding of the leaflets occurs during the night, until about sunrise, the fully exposed (day) position being attained about 40 minutes later.

It seems very probable that the movements of the petiole in this and other plants investigated by Darwin and others were rightly interpreted by him, at least in part, as movements of circumnutation, but that the variation movements of the leaflets are of the same nature is open to very great doubt. It is probably this combination of marked circumnutation with well defined sleep movements which has led to some of the difficulties in understanding the latter.

Bose's ingenious theories regarding "nyctinasty" depend on the correctness of his statement that the movements are gradual and spread over practically the whole of the day and night, except from about 1 p.m., to 6 p.m. It would therefore appear that they can only apply to those plants (if any) for which the statements are substantially correct.

It is not to be supposed that the theory outlined above regarding the sleep position will immediately and completely solve every case that presents itself, but of the 30 plants investigated by the writer: only *Cassia Tora* and *C. occidentalis* appear impossible to reconcile, while some other species of *Cassia* investigated by Darwin and others are equally difficult to explain, whether on this or any other hypothesis.

Apparently these *Cassias* constitute a special problem in the physiology of sleep movements, which might very well be investigated by someone with more time at his disposal, and a larger stock of patience, than the writer.

IV. Summary.

The characteristic sleep positions of some of the commonest Indian plants are described and figured; they are contrasted with the day positions, and the movement from day to night position and back described in certain cases. Most of them are referable to one or other of the three types figured by Kerner.

A theory is brought forward that the night and not the day position is that "normal" to plants and that therefore there is no such thing as "nyctinasty". The movement so-called is merely the return of the plant to its normal position after the stimulus is withdrawn which keeps it during the day in another position, regarded here as one of physiological strain. Those plants in which such movements are not seen either have a normal position suited to their daylight requirements, or have not sufficient 'elasticity' to return to the normal position after once departing from it.

The views of Sir J. C. Bose on "nyctinasty" are criticised.

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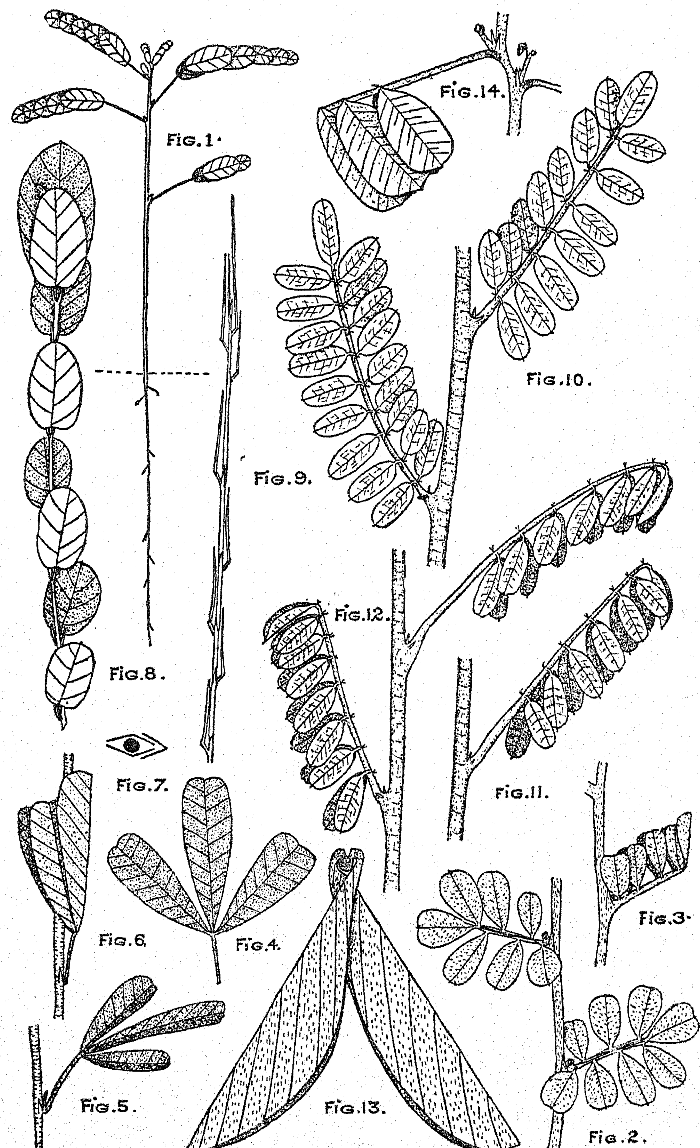
Fig. 1.
Fig. 14.
Fig. 10.
Fig. 9.
Fig. 8.
Fig. 12.
Fig. 7.
Fig. 11.
Fig. 6.
Fig. 4.
Fig. 3.
Fig. 5.
Fig. 13.
Fig. 2.

VI. Explanation of figures in Plate.

Figure 1. Phyllanthus Niruri *Linn.* Night position × $\frac{2}{3}$.

„ 2. Indigofera enneaphylla *Linn.* Day position × $\frac{3}{4}$.

„ 3. The same. Night position × $\frac{3}{4}$.

„ 4. Crotalaria medicaginea *Lamk.* VAR. neglecta *Baker.* Leaf from above. Day position × $\frac{1}{2}$.

„ 5. The same. Partly from the side × $\frac{1}{2}$.

„ 6. The same. Night position. Side view × $\frac{1}{2}$.

„ 7. The same. Night position. Transverse section × $\frac{1}{2}$.

„ 8. Alysicarpus vaginalis *DC.* Night position. Face view of leaves × $\frac{1}{3}$.

„ 9. The same. Profile view of leaves × $\frac{1}{3}$.

„ 10. Indigofera Gerardiana *Wall.* Part of a vertical shoot in the day position facing the upper surface of the leaves × 1.

„ 11. The same. Part of a similar shoot in the night position, looked at from the same side × 1.

„ 12. The same. Similar to figure 11 but looked at from the reverse side. × 1.

Figures 10 to 12 are from sketches made on the spot by my wife,

„ 13. Tephrosia villosa *Pers.* Rachis cut across and showing pair of young leaflets. Night position × $1\frac{1}{2}$.

14. Cassia Tora *Linn.* Night position × $\frac{1}{3}$.

MADHAVLAL RANCHHODLAL SCIENCE INSTITUTE,
AHMEDABAD.

September 16, 1922.

VEGETATIVE REPRODUCTION BY ROOT RUNNERS IN TWO SPECIES OF *Clerodendron.*

BY

R. H. DASTUR, M.Sc., F.L.S.

Introduction.

Although vegetative propagation by stem runners or suckers is of common occurrence, comparatively few cases are known where ordinary soil roots give rise to adventitious shoots. Kerner and Oliver (*3*) mention the Aspen (*Populus tremula*) as forming numerous adventitious shoots on the roots of a tree when it is cut down. The shoots are endogenous in origin and form a connection with the root cambium. These 'radical buds' as they have been termed, are of very common occurrence and are noticed on a host of plants from trees down to the herbs. It would be wrong to suppose that such buds only arise when the aerial parts of the plants have been injured or destroyed, though that is the frequent cause, but not a few plants develop radical buds when the aerial parts have become decrepit or are dying from natural causes. The same authors have described similar phenomena in the case of *Ailanthus glandulosa*, *Liriodendron tulipifera* and *Maclura aurantiaca* when they grow old and also in the case of shrubs such as Raspberry, Hawthorn, Barberry, Lilac, Rose and others when they wither. It is evident from the above that the radical buds are not found on young and healty plants.

Coulter, Barnes and Cowles (*1*) cite the instances of Silver poplar, Osage orange and *Sequoia semipervirens* and state that these perennials may be said to possess a capacity of perpetual existence so far as root duration is concerned.

Strasburger (*5*) also mentions the occurrence of adventitious shoots from the roots of herbaceous plants (*Brassica*, *Anemone*, *Convolvulus*, *Rumex*), bushes (*Rubus*, *Rosa*, *Corylus*), and trees (*Populus*, *Ulmus*, *Robinia*) and state that these shoots are endogenous in origin.

It appears from the above that the formation of buds on roots is a phenomenon of *Senescence* (*4*) though the term is not used. When these plants grow old or decay on account of natural causes, or when they are artificially destroyed, they continue their individual existence by giving rise to adventitious shoots. But the occurrence af adventitious shoots in young and healthy plants led to the investigation described below.

Investigation.

One plant of *Clerodendron infortunatum* Linn. was planted in the author's garden in February 1921, and after about eight months new shoots of the same species made their appearance around the original plant. A similar phenomenon was observed in the case of *Clerodendron fragrans* R. Br. which was planted at the same time at a distance of about six feet from *Clerodendron infortunatum* Linn. It was evident that these new shoots did not grow from seeds, as the original plants had not set any seeds and no plants of the same species were growing in the vicinity. A few daughter shoots were carefully dug out and it was noticed that they grew from runners at a depth of about four inches below the surface. These runners were directly connected to the roots of the original plants (Fig. 1). The daughter shoots first appeared as adventitious buds on the runners (Fig. 1. d & e), which grew vertically and emerged from the ground, the runner itself continuing to grow horizontally and producing fresh adventitious buds. The distance at which new buds appeared on the runners was not constant. It varied from three inches to three feet. The runners produced roots on the under surface which grew vertically downwards, and the runners frequently gave rise to lateral branches (Fig. 1. f.) which in turn produced adventitious buds. If the apex of a daughter shoot, while pushing its way outside happened to die (Fig. 1, c.) secondary adventitious buds appeared just below the dead apex of the shoot. (Fig. 1. h.).

The daughter shoots of *Clerodendron infortunatum* Linn. lead a dependent existence for only a short time. Roots are given out from their base, which grow strongly and geotropically and so resemble tap roots (Fig. 2. g.). But the production of roots is much delayed in the case of *Clerodendron fragrans* R. Br. A shoot of six inches in height above the ground surface has no roots of its own but derives its supply of water and salts from the parent root. Later on a thin root is given out from its base. The roots of the daughter shoots give rise to new runners which produce fresh adventitious buds. The daughter shoots remain attached to the parent runners in spite of the production of their own roots. The separation of the daughter shoots takes place by the death of the runners though the parent plant is living and healthy.

Stem runners are generally distinguished by the presence of scaly leaves and the formation of buds. But no scale leaves were found on these runners and on carefully digging out whole runners, it was seen that they terminated in root caps and not in buds. The fact that they were roots, was further supported by a transverse section of them

at a distance of about three inches from the apex, showing six groups each of xylem and phloem arranged on alternate radii. The runners contain a large amount of reserve starch.

It was considered interesting from the oecological point of view to show the rate of invasion by these plants into new ground and some records of the distance covered by them in a definite period of time were kept. *Clerodendron infortunatum* Linn. gave rise to six new shoots in a period of about six months within a circle of five feet in radius, three of them attaining a height of about six inches above the surface. *Clerodendron fragrans* R. Br. propagated itself very profusely. As many as twenty shoots appeared within a circle of eight feet in radius in the same period of time. Four of these shoots attained a height of about $1\frac{1}{2}$—2 feet and gave rise to new shoots.

Conclusion

So far as the author is aware, no mention is made any of healthy and vigorous plant giving rise to adventitious buds on its roots, except of the ordinary forestry practice of "coppicing" the Teak which is a case identical with that of the Aspen quoted by Kerner and Oliver (3). But it is not wholly comparable to the plants described, as the Teak tree only forms adventitious buds on the roots when cut down to the ground.

In the case of the various plants quoted above, the formation of adventitious buds on the roots takes place only when they are artificially destroyed or when they die of old age, and so far as the published accounts of such cases are known the production of adventitious buds from root runners on *young and healthy plants* is *unique*, as *all* previous records appear to be of plants cut down on exhibiting senescence. Hooker (2) describes *Clerodendron infortunatum* Linn. as gregarious and this investigation has shown *why* these plants are gregarious. It is intended to study the embryology of these plants at the next flowering season to determine whether they produce mature or abortive seeds the latter being very likely the case.

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Explanation of Figures

Fig. 1. The root runners of *Clerodendron fragrans* R. Br. showing daughter shoots. $\times \frac{1}{4}$.

Fig. 2. The root runner of *Clerodendron infortunatum* Linn. showing two daughter shoots. $\times \frac{1}{4}$.

In both figures,

A. Main stem of the parent plants. B. and C. Daughter shoots G. Roots of the daughter shoots. S. Scars of the scale leaves. H. A new bud developing below the dead apex of the daughter shoot.
In Fig. 1. D and E. Adventitious buds.

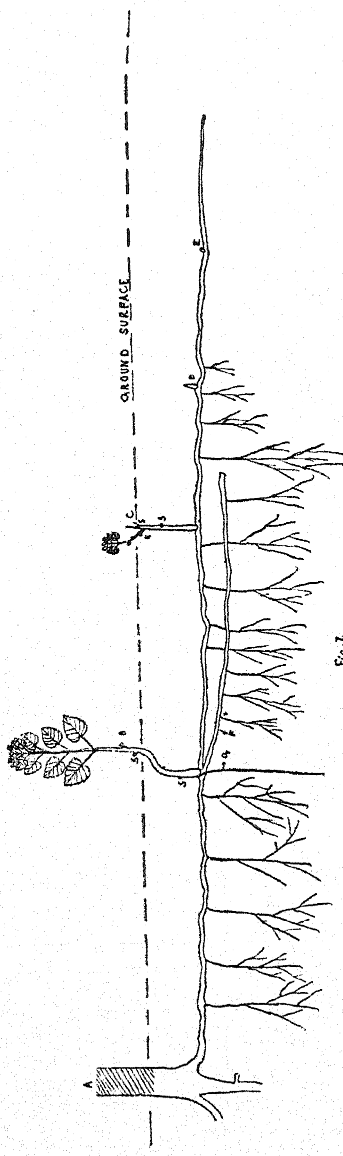

Fig. I

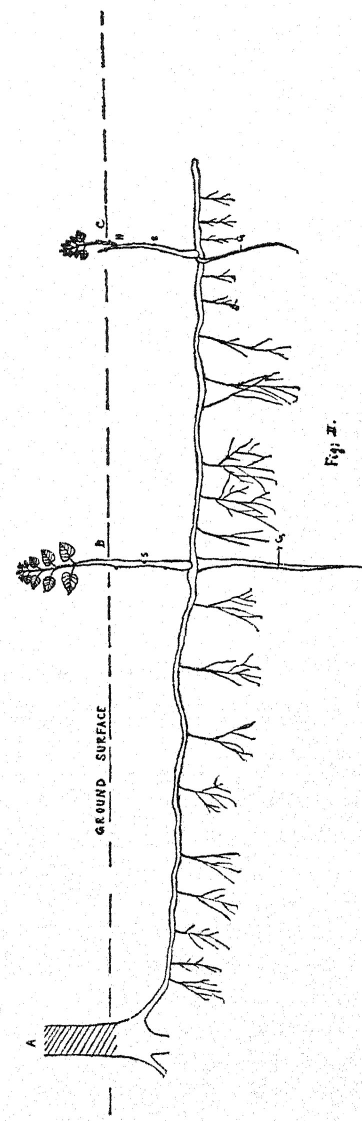

Fig. II

A NEW BULBOPHYLLUM.

BY T. PETCH.

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In October—November, 1921, Mr. A. N. Paine sent me specimens of a *Bulbophyllum* which does not appear to agree with any described species. It was found in the Maturata district, Ceylon, in heavy jungle, at an elevation of 5,600 ft. It has been named *Bulbophyllum tricarinatum*, because of the three ribs or keels on the dorsal sepal. In general appearance it resembles *Eria muscicola*, and it is possible that it may hitherto have been passed over by collectors as that species.

Bulbophyllum tricarinatum *n. sp.*

Pseudobulbs minute, ovoid, truncate at the apex, about 4 mm. high, 3 mm. diameter, crowded on a very slender rhizome.

Leaves ovate or ovate-lanceolate, 6 mm. to 3·2 cm. long, 5 mm. to 6 mm. broad, thick in the centre, incised at the apex, contracted below, usually abruptly, into a distinct petiole.

Scape filiform, expanding slightly towards the apex, up to 2·5 cm. high, bearing two to four sub-umbellate flowers, with a sheathing bract at about half its height.

Flowers sessile, greenish yellow, translucent, becoming dull orange-yellow when old; ovary green, curved, feebly ribbed, about 2 mm. long; length of flower (without ovary) about 5 mm.; bracts small, hyaline, triangular, about half the length of the ovary.

Dorsal sepal oblong, apex rounded, 5 mm. long, 2 mm. broad, appearing as long as, or slightly shorter than, the lateral sepals in the open flower, three-veined, distinctly keeled along the veins, especially at the base, frequently with a small projecting tooth on the median rib just below the apex.

Lateral sepals semi-ovate, inequilateral, apex obtuse or truncate, united by their inner edges up to halfway or nearly to the apex, adnate to the foot, 4·5 mm. long, 2 mm. broad, becoming recurved and convex, three-veined, ridged when old; mentum gently rounded.

Petals small, oblong with a triangular tip, 2 mm. long, 0·75 mm. wide, one-veined.

Column short, produced into a point behind, bearing slightly curved, elongated, acute, lateral processes, which are furnished with a minute triangular tooth on the posterior side and a rounded projection on the anterior.

Pollinia pyriform, two large and two small.

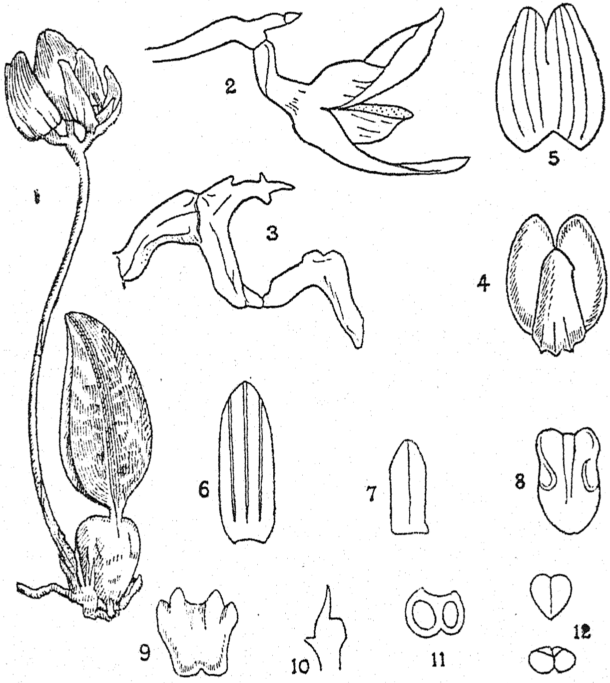
Lip tongue-shaped, hinged, channelled down the centre, abruptly bent at right angles, with two small, erect, lateral lobes on the proximal side of the bend, and an oval raised area on each side of the channel on the distal side, tomentoso-papillate except in the channel.

"Fruit apparently 6—8 mm. long, ribbed" (A. N. Paine.)

It appears to be near *Bulbophyllum moniliforme* Pear and Reichb. f., from the description, but the latter has the dorsal and lateral sepals five-nerved.

Bulbophyllum tricarinatum *Petch.*

Pseudobulbi conferti, ovoidei, 4 mm. alti, 3 mm. crassi, truncati, monophylli. Folia petiolata, ovata vel ovato-lanceolata, 6 mm.—3.2 cm. longa, 5—6 mm. lata, medio incrassata, apice incisa. Scapi erecti, ad 2.5 cm. alti, filiformes, super incrassati, medio vaginati. Inflorescentiae sub-umbellatae, 2—4 florae. Flores sessiles, parvi, viridi-flavi. Bractae minutae, hyalinae, triangulares. Sepalum posticum oblongum, apice obtusum, 5 mm. longum, 3-nervium, secundum nervos carinatum. Sepala lateralia semiovata, inaequilateralia, apice obtusa vel truncata, 4.5 mm. longa, 3-nervia. Petala parva, oblonga, apice triangulari, 2 mm. longa, 1-nervia. Labellum recurvum, lingulaeforme, canaliculatum, tomentoso-papillatum; lobi laterales minuti, erecti. Columna brevis, mucrone postico productum; processus laterales, subcurvati, elongati, acuti, post dente triangulare, ante dente rotundato, ornati.



BULBOPHYLLUM TRICARINATUM, *Petch.*

Explanation of figures.

Fig. 1. Pseudobulb and inflorescence.
2. Flower, lateral view.
3. Column and lip, lateral view.
4. Flower seen from the front.
5. Lateral sepals.
6. Dorsal sepal.
7. Petal.
8. Lip, from the front.
9. Lip, from behind.
10. Lateral process of the column.
11. Operculum.
12. Pollinia, from the front and from above.

Fig. 1, x 3 : the remainder, x 5 (prox.).

THE FLORA OF SIND.

BY

T. S. SABNIS, B.A., M.Sc.

When I visited the Indian Desert in October 1917, with Fr. Blatter and Prof. Hallberg, I was struck with the characteristic flora of that region and felt that a trip to the sister Desert of Sind would greatly help towards a better understanding of the Desert Flora in general and the Indian Desert Flora in particular. On going through the bibliography of the papers on the botany of Sind, I found, that none of them had attempted to deal systematically with the Flora as a whole.

I, therefore, undertook, on behalf of the Bombay University, a trip to the Desert of Sind in October 1920, accompanied by Mr. M. D. Mistry of the laboratory Staff of St. Xavier's College. We went to Karachi by steamer and toured about by the N. W. Railway, halting at Pad Idan, Khairpur, Sukkur, Larkana, Sita Road, Sehwan and Hyderabad. Thence we proceeded to Mirpurkhas on the J. B. Railway. From Mirpurkhas we travelled along the feeder lines to Sanghar on the North and Jamesabad on the South. We then went to Choor, a station on the J. B. Railway, and from there on camel back proceeded to Umerkot, our last halting place for the investigations of the Thar and Parkar district.

I went to the Sind Desert with the main idea of supplementing my investigations on the Physiological Anatomy of the plants of the Indian Desert, which were published in this Journal (Vols. I & II.) As a classification of the plants collected is necessary before starting with my mainwork, I propose to give in Part I, a list of plants with their, localities and distribution. I have also included localities and plants, mentioned by Cooke in his Flora of the Bombay Presidency. Part II will deal with the Physiological Anatomy and Oecology of the Flora.

I wish to take this opportunity to thank Mr. G. F. Keatings, the Director of Agriculture, and other Officers of the Agricultural Department, as well as the Vazir of Khairpur State, for their assistance and guidance, without which the tour could not possibly have been a success.

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PART I.

I. Ranunculaceae.

1 RANUNCULUS *L.*

1. **Ranunculus sceleratus** *L. Sp. Pl. (1753) 551.* Loc. :—Sukkur : " River banks (9) ".

Distrib :—Temperate America, N. Africa, Europe, N. Asia, China.

II. Menispermaceae.

1 COCCULUS *D.C.*

I. **Cocculus Loeba** *DC. Syst. (1818) 529.* Loc. Karachi : "Karachi (9) ".

Distribution.—Africa, Arabia, Afghanistan.

III. Nymphaeaceae.

1 NYMPHAEA *L.*

1. **Nymphaea lotus** *L. S. Pl. (1753) 511*—

Vern. Name: *Kamal.* Loc. Larkana : Sehwan (Sab. B61 !).

Distribution.—Africa, Hungary, India, Java, Philippines. Fl.—November.

Note.—In the same tank were found *Hydrilla verticillata* Presl. and *Potamogeton pectinatus L.*

IV. Papaveraceae.

1 ARGEMONE *L.*

1. **Argemone mexicana** *L. Sp. Pl. (1753) 508*—

Vern. Name Pivla Dhutara. Loc. Hyderabad : Hyderabad, rocky plateau (Sab. B249 !); Kotri, Indus banks (Sab. B409 !). Khairpur : Mir's forest (Sab. B330 !).

Distribution.—America. Fl.—October.

V. Fumariaceae.

1. FUMARIA *L.*

2. **Fumaria parviflora** *Lam. Encyc. II (1786) 567*, **Var. Vaillantii** *Loisel (Sp.) in Desv. Journ. Bot. II (1809) 358.* (9 without locality).

Distribution.—Baluchistan, Temperate regions of the Old World.

VI. Cruciferae

1. NASTURTIUM *R. Br.*

1. **Nasturtium officinale** *R. Br. in Ait. Hort. Kew. ed 2, IV, 110 Eng.* N : The Water-Cress. Loc. : Sukkur, Sukkur fields (Sab. B 532 !).

Distribution. — Temperate Europe and Asia.

2. FARSETIA *Desv.*

1. **Farsetia Jacquemontii** *Hook. F. & Th. in Journ. Linn. Soc. V (1861) 148.* Loc :— Larkana : "Sehwan (9)" Laki, foot of the hill (Sab. B 284 !, B 131 !, B 119 !). Thar & Parkar : Nasarpur, Sandy plains (Sab. B 1045 !). (9 without locality.)

Distribution.— Baluchistan , Afghanistan, N. India, Rajputana. Fl. and Fr. October and November.

2. **Farsetia Hamiltoni** *Royle, III, Bot. Himal.* (1839) 71. (9 without locality.)

Distribution.— Afghanistan, Arabia, Algeria.

3. MORICANDIA *DC.*

1. **Moricandia tortuosa** *H. F. and Thoms. in Journ. Linn. Soc. V (1861) 174.* (9 without locality.)

4. SENEBIERA *Poir.*

1. **Senebiera pinnatifida** *DC. Mem. Soc. Hist. Par.* (1799) 144. Loc. : " Ruk Junction " (9).

Distribution.— Temperate S. America.

5. THLASPI *L.*

1. **Thlaspi arvense** *L. Sp. Pl. (1753) 646.* Loc. : " Kirthar mountains (9)" .

Distribution.— Europe, N. Africa. W. Asia.

6. PHYSORHYNCHUS *Hook.*

1. **Physorhynchus brahuicus** *Hook. Icon. Pl. (1852) II 821, 822.* Loc : Karachi "Thano-Bula-Khan" (9) ; Soorjana Hills, 1,800 ft. (Ticehurst 30,872 !, 30,875 !) Larkana : Laki Hill (Ticehurst 28116 !) " Brahuic Hills " (9).

Distribution.—S. Persia, Baluchistan and Afghanistan. Fr ; Feb.

7. BRASSICA *L.*

Brassica Sp. Loc : Hyderabad : Hyderabad, fields (Sab. B45 !) Larkana : Larkana, fields (Sab. B97 !, B102 !). Thar& Parkar : Mirpurkhas, fields (Sab. B1183 !). Fl. October and November.

(To be continued).

NOTES

Professor Shivram Kashyap has resigned the Secretaryship of the Indian Botanical Society. All communications should hereafter be addressed to Dr. B. Sahni, Professor of Botany, Lucknow University, Lucknow.

Professor T. G. Yuncker of the De. Pauw University, Green Castle, Indiana, writes that he is making a study of the species of *Cuscuta* and would very much like to see representatives of this genus from India and neighbouring countries. Will readers in India have this in mind, and send to Professor Yuncker specimens of the plant, with flowers and fruit if possible and the name of the plant it was found on.

CURRENT LITERATURE.

Fungi

Bose S. R. One new species of Polyporaceae and some Polypores of Bengal—*Annales Mycologici, Vol. XIX, No. 1/2, 1921.*

The author gives a description of a new species of *Fomes*, *F. rufolaccatus* found growing on a dead tree in the Punjab Himalayas. Its nearest relative appears to be F. pinicola, but this new species has larger pores. Other species noted and described are *Polyporus, lazonensis* Murrill, *Fomes durissimus* Lloyd and *Trametes fuscella*, Leveille. The paper is illustrated with photographs of all these species.

P.F.F.

Sundaraman, S. The Coconut-bleeding Disease. *Bulletin No. 127 of the Agricultural Research Institute, Pusa, 1922.*

This curious and wide spread disease of the coconut palm shows itself at first in an oozing of brown liquid from cracks in the stem. In more advanced stages the centre of the stem becomes a cavity filled with a thin yellowish fluid. The tree ceases to bear nuts, the crown dwindles and the tree dies, The fungus belongs to the genus, Thielaviopsis, and is allied to a species which attacks both Sugar cane and Pine apples.

By infection experiments the author determined that the fungus is able to attack the Palm only through an injury to the surface. He does not suggest how infection is carried in nature from one tree to another, but he recommends that the diseased part be cut out and the place treated with tar ; and gives an instance of success following this treatment.

P.F.F.

Sundaraman, S. Helminthosporium Disease of Rice. *Bulletin No. 128 of the Agricultural Research Institute, Pusa, 1922.*

This fungus forms dark brown spots on the leaves, leaf-sheaths and glumes. It appears not to be a very serious disease, but is apt to become prominent with continued heavy rain or cloudy muggy weather. Sometimes the nodes are blackened, and in advanced cases the glumes become covered with a dense black fluffy mass of spores and sporophores. The grain inside are then found shrivelled up. The spores germinate readily in water, but in the experiments conducted the disease spots did not spread much.

P.F.F.

Morphology

Arber, Agnes. On the Nature of the Blade in Certain Monocotyledonous leaves. *Annals of Botany, Vol. XXXVI, July, 1922, pages 320-351.*

The development is described of the leaves in a number of plants of the cohorts or families, Helobieae (Potamogeton, Aponogeton, Sagittaria

Hydroharis), Palmæ (Areca, Oreodoxa), Cyclanthaceae (Carludovica), Araceae (Calla, Arum, Epipremum, Pistia), Liliaceae (Veratrum, Smila, Riphopogon), Amaryllidaceae (Curculigo), Dioscoreaceae (Tamus, Dioscorea), Iridaceae (Tigridia); and to compare with them in Aristolochia, Polygonum, Populus, Fagus, Cercis, Trifolium, Syringa, in which similarities of development or form exist.

While in general the development of the blade in these monocotyledonous leaves can be matched among the dicotyledons, Dr. Arber finds one great difference to exist in that the plication of those Monocotyledonous leaves which show it is due to invagination, the thick leaf primordium being cut into from the ventral and dorsal sides; whereas in Dicotyledons, the folding when it occurs is developed as the leaf grows, and a circinate vernation is caused by the edge of the blade curling in. This lends some support, Dr. Arber considers, to the Phyllode Theory.

P.F.F.

Arber. Agnes. Leaves of the Farinosae. *Botanical Gazette, Vol. LXXIV, No. 1, September, 1922, pages 80-94.*

In this paper Dr. Arber describes the structure of the leaf in the various families of this Cohort. She finds that on the basis of the Phyllode Theory of the monocotyledonous leaf, the leaves of the Farinosae can be classified into six groups, 1. Phyllodes with a sheathing base and ensiform limb, 2. Phyllodes with a sheathing base and limb differing very little from the normal petiole, 3. Phyllodes similar to 2, but with the petiolar part much reduced, to a mere point (Eriocaulon cuspidatum), 4. Phyllodes similar to 3 but consisting of leaf base only (other species of Eriocaulon), 5. Phyllodes with the whole or distal portion of the petiole expanded in a horizontal plane, with inverted and normal bundles (Pontederia), 6. Phyllodes as in 5, but with normal bundles only.

She then goes on to show similar structures among Helobieae and Liliflorae, and concludes that this frequent parallelism of development is due to the limitations imposed by the absence of a true lamina, and the consequent modification, in its place, of the petiole.

P.F.F.

Arber. A. On the Development and Morphology of the Leaves of Palms. *Proc. Roy. Soc. Lond. B., Vol. 93, 1922, pages 249—261.*

In this paper Mrs. Arber continues her examination of the leaves of Monocotyledons, (a previous paper of the series was noticed in this Journal Vol. II, pp. 58, 59); and comes to the following conclusions with regard to the ontogeny, development and homology of the Palm-leaf.

(1) The peculiar folding of the mature leaf, whether fan-type or feather-type, shows itself in the extremely young leaf, (the several stages were shown in under half a millimetre) as a series of invaginations, first on the upper then on the lower side, alternately. The formation therefore is produced not by folding (as of a thin lamina pushed in from the sides) nor by splitting of a solid mass into thin layers, both of which explanations have been put forward by other authors, but by locally a more rapid growth of

the epidermal tissue than of the cells immediately below, so that grooves are so to speak pressed in on both sides.

2. The membrane which covers the unopened leaf like a bag of tissue paper, is formed by a proliferation of the epidermal cells at the mouths of the invaginations, closing these up. It is therefore a secondary structure, and is not the results of splits starting inside and not quite reaching the surface, as has been suggested.

3. The solid tip, or "gland ", at the end of the first seedling leaves, is not a separate organ, but is due to the invaginations not reaching the tip of the lamina.

4. The ligule-like scale at the base of the lamina of fan-leaves, and the sometimes corresponding scale on the dorsal side, are due to the invaginations failing at their proximal limit to reach the epidermis so that part of this petiolar-surface is left overarching the base of the tissue. There is no ligule in the proper sense.

In a final discussion of the morphology of the Palm leaf, Dr. Arber maintains that the palm-leaf, above its sheathing base, is homologous with the petiole of the Dicotyledon, the lower part being petiolar in nature, the upper expanded and invaginated like a folded lamina. It is therefore a petiolar-phyllode, with a pseudo lamina, as in many other Monocotyledons,

The paper is an important contribution to this subject, and deserves the attention of all teachers of morphology.

P.F.F.

Books

The Ferns of Bombay. By E. Blatter, S. J. Ph. D. F. L. S., and J. F.d'Almeida B. A., B. Sc. 22 pages, 17 plates (2 coloured) and 45 text figures. *Bombay D. B, Taraporevala Sons and Co., Rs. 7/8.*

To the Visitor to one of our hill-stations on the Western Ghats for the first time, probably the most striking feature of the vegetation is the beauty and richness of the ferns. For here we see growing in their natural surroundings sand and to a perfection unattainable elsewhere, so many of these essentially shade and moisture loving plants, which on the plains must be protected from sun and wind. But while this is true, it is also unfortunately true that of no group of the larger plants is it so diffincult for the ordinary visitor to become friends with, to know individually, the various genera and species, because identification depends on obscure and often microscopic details, and there has been till now no purely local or easily consulted book. Messrs Blatter and d'Almeida have supplied this need, and have done it well.

About an eighth of the book is devoted to an introduction, in which after enumerating the various works consulted the authors lead their readers by a kind hand through the usually dreary land of technical terms, explain the mystery of a fern's birth and life, tell him of the distribution of these plants in the Presidency, and give some sound advice on the cultivation of ferns on the plains. These are unusual features in a book of this kind, but entirely good, and the only addition that suggests itself is in the last section, that a rockery should be so constructed as to be water holding, rather than the reverse, (and this requires that the stones be specially built up to

diminish drainage) and that fern roots like being crowded, and should not be divided as soon as they have filled the pot, a peculiarity which the māli can only with difficulty be made to understand.

The greater part of the work contains descriptions of the genera and species, with a key at the end, and is illustrated with figures which show remarkably well the essential details and in most cases also the general appearance of the plant or frond. The descriptions are concise and err if at all in an unbending adherence to strictly botanical terms. But the figures are good, and on the whole this part is so well done that the book will be of interest and value not merely to the resident or visitor on the hills, but also to garden lover on the plains, for turning over the pages one meets many friends of the fernery as well as of the mountains, and after all practically every one of our garden ferns must have been brought originally from the nearer hills.

The authors are to be congratulated on a very useful little book, and one which can heartily be commended to all garden-lovers, whether on the plains or on the hills. The size is convenient for the pocket and the printing throughout of the high standard we have learned to expect from the Dioscesan (formerly the S.P.C.K.) Press, Madras.

P.F.F.

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ON THE LEAF-TIP TENDRILS OF CERTAIN MONOCOTYLEDONS

BY

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Keddey Fletcher-Warr Student of the University of London.

1. Introduction

It has long been known that certain genera among the Liliaceae, and the one genus *Flagellaria* among the Farinosae, are distinguished by elongated leaf-tips which function as tendrils. Though I have been for some years engaged on a study of Monocotyledonous leaves, I have not found, in the literature of the subject, any connected account of the structure of these peculiar tendrils; it has therefore seemed to me worth while to attempt a comparative examination of them. In carrying out this study I have been obliged to rely chiefly upon herbarium specimens, since none of the species in question are native to Western Europe. For supplies of material I am indebted to the kindness of the Superintendent, Royal Botanic Garden, Sibpur, Calcutta; the Director, Royal Botanic Gardens, Kew; the Director and the Superintendent, the Botanic Garden, Cambridge; Miss G. Lister, and Professor A. C. Seward, F.R.S.

2. The Leaf-tip Tendrils of the Liliaceae

Leaves with tendril apices are characteristic of some or all the species in the case of five genera of the Liliaceae :—

Gloriosa			
Littonia	...	... Melianthoideae	Uvularieae
Sandersonia			
Fritillaria	...	... Liliaceae	Tulipeae
Polygonatum	...	... Asparagoideae	Polygonateae

Gloriosa

The best-known of the Monocotyledonous genera with tendril leaf-tips is *Gloriosa*. Many authors have referred to these tendrils, but I have met with no description of their anatomy; their physiology was studied by Darwin (7). I have been able to examine living plants of *Gloriosa superba*, L., a species which is cultivated in hot-houses in England. Here the earlier leaves, borne by the long climbing shoots, do not terminate in tendrils. They thus agree with the juvenile leaves of the seedling, which, in those species about which we have records, are said to be non-tendrillar (7 and 8). Pl. II, Fig. 12 A, shows the second aerial leaf of a shoot of *G. superba*; at the base it has a short closed sheath. The first aerial leaf of the same shoot was similar, but with a much longer closed sheathing base. According to Queva (9, p. 59) the first four leaves of the principal axis have closed sheaths. Higher on the shoot the mature type of leaf is borne; it differs from those just described in the presence of a terminal tendril, and in the absence of a closed sheath at the base. Pl. II, Fig. 12 B, shows the end of a shoot with a number of leaves with apical tendrils, which curve downwards, so that the upper surface of the leaf forms the outer surface of the coils. When the tendril grasps a support, as in the lowest right hand leaf of this figure, it thickens considerably. Fig. 12 C shows a case in which the tendril tips of four leaves have become firmly interlocked. Pl. I, Fig. 1 represents the leaf of another species, *G. virescens*, Lindl., with its tendril tip. Though the particular leaf drawn was of a wider shape than those of G. *superba* shown in Pl. II. Fig. 12, the species is variable in this respect, and *G. virescens*, Lindl., var. *angustifolia* may even have linear leaves. *G. virescens* does not seem invariably to develop tendrils; there is a flowering plant from Nyassa-Land in the Kew Herbarium, which shows no tendril formation.

The anatomical structure of the leaf-tip and tendril in *Gloriosa superba* are represented in Pl. 1, Figs. 2 and 3. Fig. 2 A indicates the structure of the leaf-tip just below the tendril; the bundles are separate, and each has a patch of fibres above and below. In Fig. 2 B the tendril is thickening, and the amount of fibrosis has greatly increased, so that the bundles are all involved in one continuous sheath of fibres. Nearer the apex (Fig. 2 C) the tendril is still thicker—indeed it has become roughly circular in section—the bundles are reduced to three, presumably by the fusion of the laterals on either side, and the fibrous sheath has disappeared, except for patches in connexion with each of the three phloem groups. Higher still (Fig. 2 D) these three strands have fused into one vascular complex.

There seems to be a great deal of variation in the degree to which the tendrils thicken and become sclerised. Fig. 3 A is a transverse section (on a smaller scale) of a tendril which is more fibrous than that drawn in Fig. 2.

Fig. 3 B shows in greater detail the median bundle from another section of the same tendril, at a level where the fibrosis is less extreme. The xylem of the median bundle is narrowed and elongated—possibly owing to the pressure of the fibres in which it is embedded—so that, considered in three dimensions, it forms a thin ribbon in the median plane of the leaf.

Littonia

The genus *Littonia* is nearly related to *Gloriosa*; I have not seen seedlings, but according to Queva (**9**, p. 139) the earliest leaves are non-tendrillar, as in *Gloriosa*. The tendril-tips of the mature leaves of both genera resemble one another in form and structure. Pl. I, Fig. 4 shows the leaf of *Littonia modesta*, Hook. and the changes in anatomy which take place in the passage from the tip of the limb to the tendril can be traced in Figs. 5 A—D. As in *Gloriosa*, the bundles are reduced to three in the tendril, and the partial fibrous sheaths are replaced by a single mass of fibres, in which the vascular strands are embedded. I was unable to obtain sections nearer to the apex of the tendril than that shown in Fig. 5 D, but there is little doubt that—as in *Gloriosa*—the three bundles fuse, for at the level of Fig. 5 D their xylems are separated by the width of one element only.

Sandersonia

The monotypic *Sandersonia aurantiaca*, Hook., of S. Africa, is a third plant nearly allied to *Gloriosa* and *Littonia*. Pl. II, Fig. 6 shows a tendrillar leaf of this species. Tendrils are apparently not always formed, for in most of the flowering specimens in the Kew Herbarium, the leaf apices, though long and slender, show no definite signs of coiling. The structure of the leaf-tip and tendril is illustrated in Figs. 7 A—C.

Fritillaria

The Uvularieae are the only tribe of the Liliaceae including more than one genus with leaf-tip tendrils, but the Tulipeae and the Polygonateae each contain one genus with the same peculiarity. Among the Tulipeae, certain species of *Fritillaria* have tendril leaves. Pl. II, Fig. 10 A shows a whorl of such leaves in the case of *F. verticillata*, Ledebour. This species is of particular interest, since some of the leaves show great reduction in connexion with tendril formation. Fig. 10 B. for instance, is from a shoot in which the lower leaves were linear, but the uppermost (those represented) were

so much narrowed as to be actually thread-like, so that the whole leaf may be said to be reduced to a tendril. Those *Fritillaria* tendrils of which I was able to cut sections, were markedly dorsiventral, and not fibrous (Fig. 11). As in the other Liliaceae, there was a three-stranded stage (Fig. 11 C); Fig. 11 D shows the apex of a tendril in which the vascular system consisted of one bundle.

Polygonatum

Pl. II, Fig. 8, shows the apex of a shoot of *Polygonatum sibiricum*, Delar., a plant which is known from Northern Asia and the Himalayan region. The coiled apical region of the tendril is flattened and ribbon-like; it was 1·5 mm. wide in the largest example I have seen. Pl. II, Figs. 9 A—E, show the anatomical structure of the tip of the limb and the tendril in this species. The bundles are reduced to three in Fig. 9 D and to one in the tip of the tendril, Fig. 9 E. A striking feature is the thick-walled epidermis on the lower side in the region of the midrib. The epidermis is two to three cells deep at the level of Figs. 9 B and 9 D; it is seen in greater detail in Fig. 9 C. This peculiarity is gradually lost, however, towards the apex, and in Fig. 9 E the lower epidermis in the midrib region consists of only a single layer of large cells.

So far as I have been able to observe, the tendril of *Polygonatum* differs from that of *Gloriosa*, *Littonia* and *Sandersonia*, and resembles that of *Fritillaria*, in not becoming fibrous. But in the thickest tendril I was able to examine, the xylem of the median bundle was somewhat more developed than in the example figured here.

3. The Leaf Structure of the Flagellariaceae

In the case of the Liliaceae we find five genera with leaftip tendrils, distributed among three of the tribes of a very large Family, including nearly 200 genera. The only other genus among Monocotyledons which possesses tendril leaf-tips—*Flagellaria*—occupies however a very different position systematically, since it is one of the three genera which make up the small Family, Flagellariaceae, belonging to the Farinosae. In a recent paper (6) I have given a sketch of the leaf structure of this Cohort, omitting, however, this particular Family, because it seemed better to consider it in connexion with the leaf tendrils with which we are here concerned. Since the leaf anatomy of the Flagellariaceae appears to have remained hitherto undescribed, I propose here to say something about all the three genera, though *Flagellaria*, which gives its name to the Family, is the only one which possesses tendrils.

Flagellaria

The leaf of *Flagellaria indica*, L., is shown in Plate III, Fig. 13. It has a conspicuous sheath (*sh*) sharply separated from a well-marked limb (*l*) terminating in a tendril (*t.*) For comparision I have drawn a seedling (Fig. 14), in which it will be seen that scale leaves with no differentiated blade (*sc.*) are succeeded by juvenile foliage leaves (such as *l.*) which have expanded limbs, but in which the apical tendril is absent, its place being taken by an acuminate tip. The leaf-sheath is longer in proportion to the limb in the juvenile leaves than in the mature leaves. I do not know how soon tendrils make their appearance; they were still absent in the oldest seedlings I have been able to obtain, which bore ten leaves, and Darwin records that a young plant under his observation, which was 12 inches in height and bore 15 leaves, had not a single leaf produced into a tendril (7). The tendril, which coils forwards towards the ventral surface of the leaf, tends rather to a flat ribbon-like form. The anatomy of the leaf-tip and tendril is illustrated in Figs. 15 A—C. Fig. 15 A shows the structure of the leaf-tip just below the tendril. The median bundle (*m. b.*), the main laterals (*m. l.*) and the minor bundles, have each an individual fibrous sheath. Fig. 15 B is a section of a somewhat thickened tendril, in which the mesophyll, forming the main part of the section, is thick-walled but not sclerised. The bundles, which lie in one horizontal plane towards the dorsal surface of the tendril, are enclosed in a common sheath of fibres, which are more densely sclerised and thicker-walled on the side towards the phloem. Fig. 15 C shows the structure of the thickest coiled part of another tendril. The bundles, as in the previous case, have a common fibrous sheath, while the mesophyll has also become sclerised in the region indicated by cross-hatching.

Susum

This genus is characterised by large simple leaves, which are said sometimes to exceed six feet in length. I have not been able to examine them as thoroughly as I should wish, but I have had the opportunity of cutting sections of one leaf of *S. anthelminthicum*. Blume, whose lanceolate limb was markedly asymmetrical about the midrib. The structure of the leaf-sheath is shown diagrammatically in Plate III, Figs. 16 *A* and *B*. In the thicker parts of the leaf-base there are several series of bundles, each bundle being enclosed in a massive coat of fibres. There is a series of small strands close to the upper, and another close to the lower surface; in the members of both these series the vascular tissue occupies only a

minute proportion of the bundle area—the remaining space being filled by a mass of fibres. These bundles may be compared with some of those, for instance, in the leaf of *Agave*, and may be considered as having entered on the down-grade path which leads from a true vascular bundle to a mere strand of fibres (1, pages 493-4). These small superficial bundles of the *Susum* sheath have also another interesting peculiarity—namely that the members of the series towards the upper surface (*i.b.* 2) are seen to be inversely orientated in all those cases in which the vascular tissue is well enough developed to be distinguishable. There are also some larger bundles (*i.b.* 1), not belonging to the upper inverted series, but agreeing with it in having their xylems directed downwards and phloems upwards. In the marginal region of the sheath (Fig. 16 B) the inverted bundles die out; in this figure only one is visible. Inversely orientated strands can be followed up into the midrib region of the limb.

Joinvillea

The leaf of *Joinvillea elegans* Gaudich., differs greatly from that of *Flagellaria* or of *Susum*. The following description of the anatomy is based upon the study of a single dried leaf. The top of the sheath (*sh.*) and the base of the "plicate" limb (*l.*) are represented in Plate III, Fig. 17. There is a conspicuous ligule (*lig.*) at the junction of the two. Fig. 18 A shows the structure of the leaf sheath; as in *Susum*, there is more than one series of bundles; each strand is enclosed in a fibrous coat, and some of the strands even consist exclusively of fibres. The hypodermal region below the ventral surface of the sheath is conspicuously meristematic, the cells being arranged in radial rows; Fig. 18 B shows these parallel files on a larger scale. Meristematic activity in this region is not uncommon in Monocotyledonous leaf-sheaths. As indicated by Figs. 18 C and D, the plication of the limb originates by invaginations which penetrate from the dorsal surface between the main bundles, while invaginations belonging to an alternating series pass in from the ventral surface. The bases of these longitudinal grooves are occupied by enlarged epidermal cells, marked with a cross in Figs. 18 C and D. These cells are a striking feature of sections of this leaf, since they, and the smaller hypodermal cells beneath them, remain clear and colourless when the preparations are stained with methyl green; they are shown on a larger scale in Fig. 18 E. It will be noted in Fig. 18 D, drawn from a section of the limb not far from the apex, that the bundles have come to lie slightly laterally to the ridges and furrows, and thus not immediately above and below the enlarged cells. I have

already described the occurrence of similar hypertrophied epidermal cells lining the bases of invaginations in the leaf of *Curculigo recurvata*, Dryand. (5, Fig. 17, p. 341); but there are differences in detail, since in *Curculigo* the hypoderm is not involved and the passage between the enlarged and normal epidermal cells is more gradual. But in both cases these enlarged epidermal cells are associated with the development of a plicate leaf; they appear to correspond to the "motor cells" which are concerned in the rolling and folding of Grass leaves, but differ from them in being developed on both surfaces of the leaf, instead of only on the upper surface. As I have not seen the leaf of *Joinvillea* in the living state, I cannot say whether these cells have the power of opening and closing the fan-like folds of the limb, as one might expect by analogy with the action of the motor cells of Grasses.

In previous papers I have described the origin of "plication" by invagination in the Palms **(4)**, Cyclanthaceae, Liliaceae and Amaryllidaceae **(5)**, and Iridaceae **(3)**. The case of *Joinvillea* furnishes a comparable example from the Farinosae—a Cohort in which this mode of development has not been hitherto observed.

4. Comparison and Conclusions

In general appearance, the leaf-tip tendrils of all those Monocotyledons which we have been considering conform to one simple type. Their morphological interpretation is not, however, correspondingly easy, and it is possible that the same explanation will not apply to all. The leaf of *Flagellaria* is more completely differentiated than that of the tendril-bearing Liliaceae. On the phyllode theory **(1)** I should interpret the leaf of *Flagellaria* as consisting of a sheath succeeded by a limb which is a horizontally expanded petiole, and I should thus look upon the tendril as representing the apical part of this flattened petiole. In the case of the Liliaceous genera, it may be that the morphology is, in reality, the same, and that the limb is of petiolar nature, while the leaf-sheath—in the mature tendril-bearing leaves—is reduced almost to nothing. On the other hand the limb in these species may possibly be of leaf-sheath nature, in which case the tendril may represent either the apex of the leaf-sheath, or the vestigial rudiment of a petiole. The difficulty in elucidating these tendril leaves is the greater, because there are no cases, among the Dicotyledons, of simple leaves with tendril apices, with which the Monocotyledonous cases could be compared; and in the only other tendril-bearing Monocotyledon—*Smilax*—these organs are so extremely remote in morphology and structure from the leaf-tip tendrils here described, that they are useless for purposes of comparison **(2)**.

When we come to compare among themselves the leaf-tip tendrils which we have described in this paper, we find that they present a certain general similarity, but also a number of out-standing differences. Externally the most noticeable divergence relates to the direction of coiling. Whereas in all the five Liliaceous genera the tendrils coil downward (*i. e.* the upper or ventral leaf surface forms the outer surface of the coils) in the case of *Flagellaria* the curvature is in the opposite direction—the tip curling inwards. In anatomy also—as has been shown in the descriptive section of this paper—*Flagellaria* is sharply marked off from the Liliaceous cases. If Plate III, Fig. 15 C, which represents a section of the thickened tendril of *Flagellaria*, be compared with Plate I, Fig. 3 A, in which the corresponding region of *Gloriosa* is shown, it will be seen that the type of structure is essentially different. In *Flagellaria* there is a series of bundles, recalling the arrangement met with in the leaf of *Restio*, another member of the Farinosae (6. Plate I, Fig. 1), while in the corresponding region of the Liliaceous genera, the strands are reduced to three; in *Flagellaria*, again, the main mass of the sclerotic tissue is independent of the vascular strands, instead of being closely associated with them as in *Gloriosa*. In *Gloriosa* indeed, one cannot, in the thickened tendril, discriminate between bundle-sheath fibres and fibrous cortex, but in *Flagellaria* these two regions are separate and readily distinguishable.

When we leave *Flagellaria* on one side and compare the Liliaceous genera among themselves, we find that, though the tendril anatomy of the Uvularieae—*Gloriosa* (Plate I, Fig. 3 A), *Littonia* (Plate I, Fig. 5 C.) and *Sandersonia* (Plate II, Fig. 7 C)—conforms with minor divergences to one general plan, yet this general plan is somewhat different from that of *Polygonatum* (Polygonateae) on the one hand (Plate II, Fig. 9 D), or *Fritillaria* (Tulipeae) on the other (Plate II, Fig. 11 C).

The fact that in the six Monocotyledonous genera which have leaf-tip tendrils, these organs vary among themselves, anatomically, in the way which we have indicated, is, I think, of some significance. On the theory that structure is determined by function, one might have expected to find that these leaf-tip tendrils would conform to one anatomical type, whether the plants bearing them were closely related or not. But what we actually find is that they are by no means uniform, but show among themselves just those degrees of resemblance and difference which might have been anticipated if the anatomical ground-plan of any organ be supposed to depend, not on the function it is destined to perform, but on the position, in the Natural System

of the species to which it belongs. In other words, the study of the leaf-tip tendrils of Monocotyledons leads us to the view that the general anatomical scheme on which these organs are constructed is determined by the inherent anatomical tendencies of the species, rather than by the response to a common physiological need.

Balfour Laboratory, Cambridge.

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Explanation of the Plates

PLATE I

[Throughout the plates the following notation is used :—*xy.*, xylem (black) : *ph.*, phloem, (white) ; *f.*, fibres (dotted) ; *u. e.*, upper epidermis ; *l. e.*, lower epidermis.]

Fig. 1.—*Gloriosa virescens*, Lindl., leaf from the Sudan, Kew Herbarium, (× $\frac{2}{9}$).

Figs. 2 and 3.—*Gloriosa superba*, L.

Fig. 2 A—D, series of sections through leaf apex and tendril from below upwards (× 21).

Figs. 3 A and B, thickened region of another tendril; Fig. 3 A, transverse section of tendril (× 10); Fig 3 B, median bundle from a transverse section of the same tendril, at a level where there is slightly less fibrosis than in Fig. 3 A (× 141): *ph. f.*, fibres outside phloem.

Fig. 4.—*Littonia modesta*, Hook., leaf (× $\frac{2}{9}$).

Fig. 5 A—D.—*Littonia Keiti*, Leicht. (*L. modesta*, Hook.), specimen from Temberland, Kew Herbarium, series of transverse sections upwards from below through one leaf apex and tendril (× 21).

PLATE II

Figs. 6 and 7.—*Sanderonia aurantiaca*, Hook.

Fig. 6, leaf of specimen from Swaziland, Kew Herbarium, (× $\frac{2}{9}$)

Fig. 7 A, specimen from Natal, transverse section near leaf apex (× 10).

Figs. 7 B and C, specimen from Swaziland, transverse sections nearer apex of leaf than Fig. 7 A (× 34).

Figs. 8 and 9.—*Polygonatum ibiricum*, Delar.

Fig. 8. apex of shoot with young leaves, Kew Herbarium, (× $\frac{2}{9}$)

Figs. 9 A, B, D, E, series of transverse sections of apical region of leaf, from below upwards, including tendril (× 10). Fig, 9 C, median bundle of Fig. 9 B on a larger scale (× 34); *d. e.*, thick-walled dorsal epidermis.

Figs. 10 and 11.—*Fritillaria verticillata*, Ledebour.

Fig. 10 A, a node with four leaves, slightly reconstructed, since the herbarium material used was imperfect (× $\frac{2}{9}$).

Figs. 10 B and C, examples of very narrow leaves from the Cambridge Botany School Herbarium (× $\frac{2}{9}$).

Figs. 11 A and D, transverse sections through one tendril (× 21).

Fig. 11 B, median bundle of Fig. 11 A (× 86).

Fig. 11 C, transverse section through another tendril (× 10).

Fig. 12, *Gloriosa superba*, L. (garden variety).

Fig. 12 A, second aerial leaf of shoot (× $\frac{2}{9}$).

Fig. 12 B, shoot apex (× $\frac{2}{9}$).

Fig. 12 C, tips of four leaves with tendrils interlocked (× $\frac{2}{9}$).

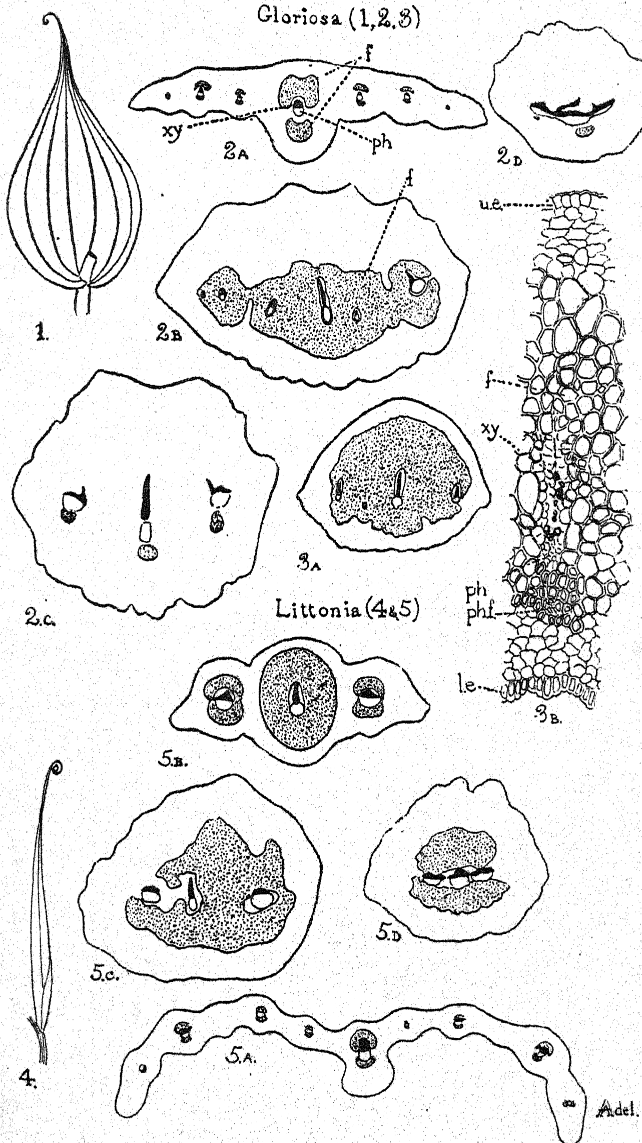
Gloriosa (1,2,3)
f
xy
ph
2A
2D
f
u.e.
1.
2B
f
xy
2.C.
3A
ph
phf
Littonia (4&5)
l.e.
3B.
5B.
5.C.
5.D
4.
5.A.
A del.

PLATE I.

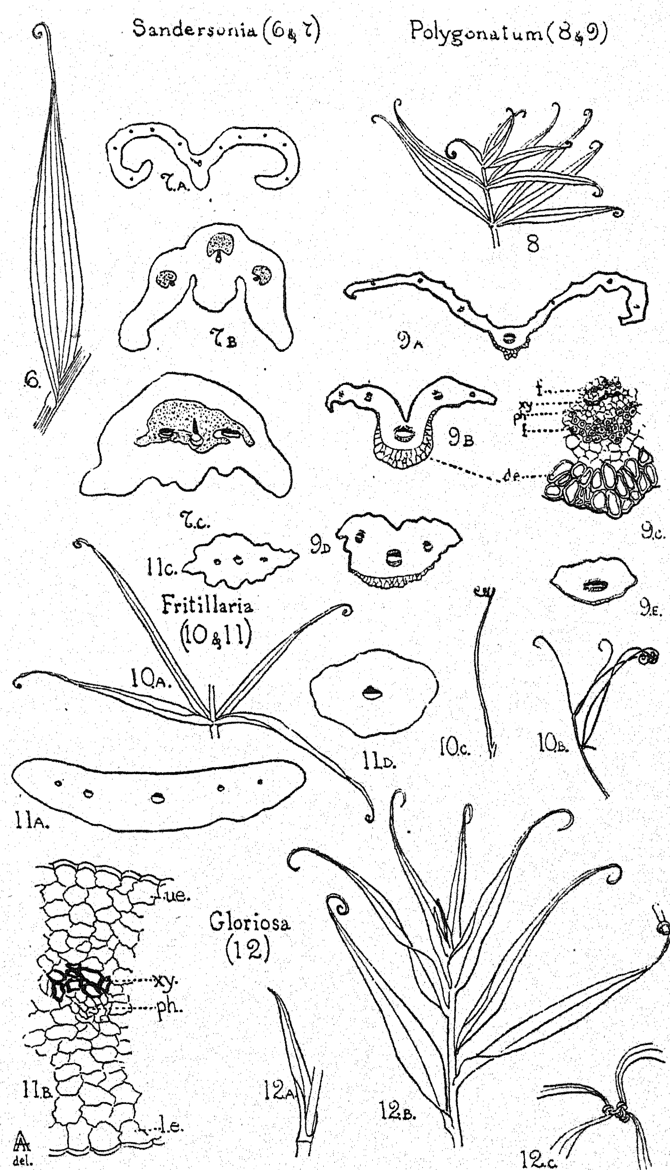
Sandersonia (6 & 7)
Polygonatum (8 & 9)
6.
7.A.
7B
7.C.
8
9A
9B
f.
xy.
ph.
f.
de.
9.C.
9D
9.E.
11c.
Fritillaria
(10 & 11)
10A.
10B.
10C.
11D.
11A.
Gloriosa
(12)
ue.
xy.
ph.
l.e.
11B.
12A.
12B.
12.C.
A
del.

PLATE II

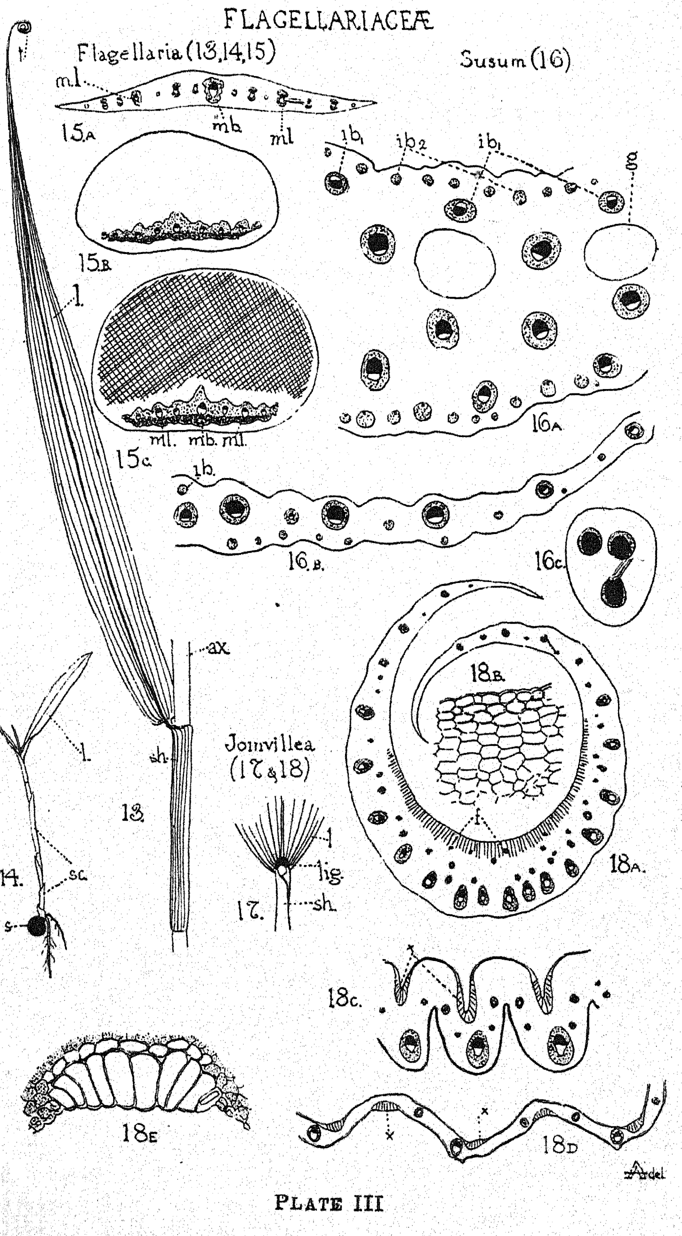
FLAGELLARIACEÆ
Flagellaria (13,14,15)
Susum (16)
ml.
mb
ml
15A
ib1
ib2
ib1
g
15B
l.
15c
ml. mb. ml.
16A
ib.
16B.
16c.
18B.
ax.
l.
sh.
13.
Joinvillea (17 & 18)
l
lig.
sh.
17.
f
18A.
14.
sc.
s.
18c.
x
18E
x
x
18D
Ardel

PLATE III

PLATE III

Flagellariaceae

Figs. 13, 14, 15.—*Flagellaria indica*, L.

Fig. 13, mature leaf ($\times \frac{2}{3}$); *ax.*, axis; *sh.*, sheath: *l.*, limb; *t.*, tendril.

Fig. 14, seedling with seed (*s.*); scale leaves (*sc.*); and foliage leaves (*l*).

Fig. 15 A, transverse section of a leaf near apex just below tendril; *m. b.*, median bundle; *m. l.*, main laterals ($\times$ 10).

Fig. 15 B, transverse section of a somewhat thickened tendril ($\times$ 10).

Fig. 15 C, transverse section of a tendril which had coiled and thickened; the cross-hatching indicates mesophyll cells which have become fibrous ($\times$ 10).

Fig. 16.—*Susum anthelminthicum*, Blume.

Fig. 16 A, transverse section of a small part of sheath region of leaf ($\times$10); $i.\ b._1$ and $i.\ b._2$ inversely orientated vascular bundles, *g.*, ? gum spaces.

Fig 16 B, transverse section of small part near margin of sheath region of leaf ($\times$10).

Fig 16 C, transverse section near tip of leaf borne on the inflorescence axis of *Susum* ? *anthelminthicum* ($\times$10). At this level the chief part of the bundle is formed by xylem; at a higher level the three bundles fuse.

Figs. 17 and 18.—*Joinvillea elegans*. Gaudich.

Fig. 17, base of leaf-limb ($\times \frac{2}{3}$); *sh.*, sheath; *lig.*, ligule: (indicated in black); *l*, plicate limb.

Fig. 18 A, transverse section of sheath, hairs omitted ($\times$ 6); *f.*, groups of fibres; the lines at right angles to the upper epidermis indicate the radial files of elements, due to meristematic activity.

Fig. 18 B, part of transverse section towards ventral surface more enlarged to show radial files of cells below upper epidermis ($\times$34).

Fig. 18 C, part of transverse section of lower part of limb, to show origin of plication by invagination, hairs omitted; the lower epidermis has enlarged cells (marked with a cross) at the base of the invaginations ($\times$10).

Fig. 18 D, part of transverse section of limb, not far from apex; hairs omitted; groups of enlarged cells in both upper and lower epidermis.

Fig. 18 E, group of enlarged cells from lower epidermis, similar to left hand group marked with a cross in Fig. 18 D, more highly magnified ($\times$86).

ON THE BIOLOGY OF THE FLOWERS OF MONOCHORIA

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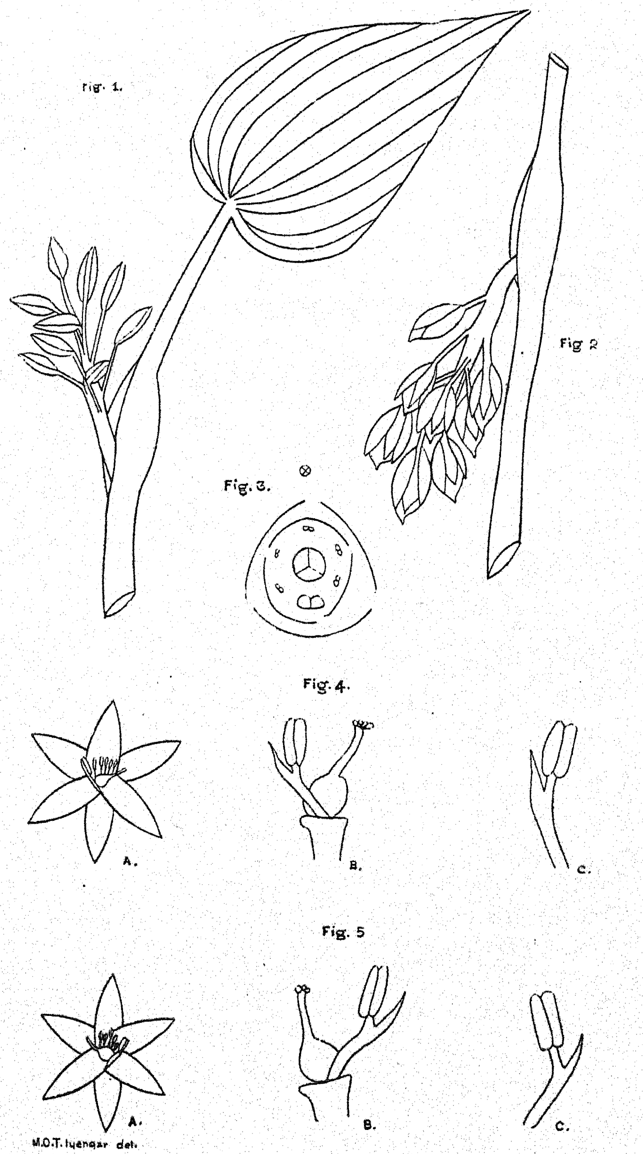
(*Read before the Indian Science Congress* 1922.)

Two species of *Monochoria*, *M. hastaefolia* Presl., and *M. vaginalis* Linn., were studied with reference to the floral dimorphism as an adaptation for cross-pollination by insects. These species are plants commonly found on the banks of streams and in marshes all over India. They have blue trimerous flowers consisting of six perianth lobes, six stamens, (five being small, yellow and sterile. the posterior fertile stamen being large and blue, with its filament spurred on one or both sides), and a three-celled superior ovary with a style and a minutely six-fid stigma, (Fig. 3). The flowers are aggregated in terminal inflorescences (symposial cymose pseu-do-racemes) which are centripetal in the smaller species, *M. vaginalis*, and centrifugal in the more robust *M. hastaefolia*, (plate I).

The flowers of both the species of *Monochoria* show an interesting form of dimorphism produced as a result of the bending of the fertile posterior stamen to one side, either to the right or to the left, and a corresponding bending in the opposite direction of the style. Thus two types of flowers are seen, (1) those in which the stamen bends to the right and the style to the left and (2) those in which the bending is reversed, (Plate II and Figs. 4 and 5.) Flowers of both types occur in the same inflorescence. But it has also been noticed that flowers opening on any one day on an inflorescence were mostly of one type.

The anthers of the posterior fertile stamen dehisce through terminal slits which may later on extend downwards; the tips of the anther and the stigma are at the same level on either side of the flowers. The importance of this dimorphism is as an adaptation for cross-pollination by insect visitors. If an insect visits the flower the anther-tip and the stigma touch the right and left parts of the body and if the insect were to visit the same type of flower no pollination could be effected. But if it were to visit the other type of flower where the positions of the anther and the stigma are reversed, it effects cross-pollination as that part of the body originally smeared

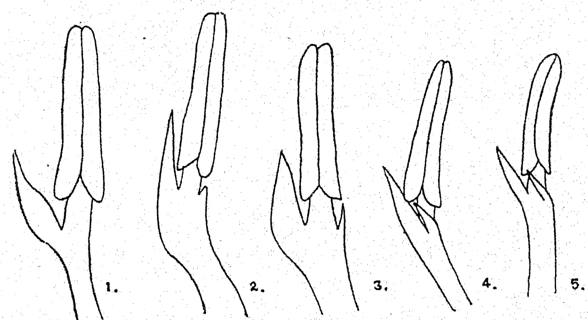
ON THE BIOLOGY OF MONOCHORIA FLOWERS.



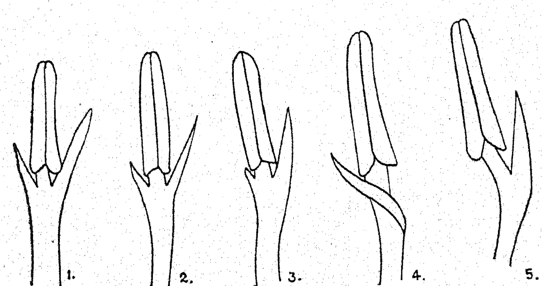
Figs. 1 & 2. *Monochoria vaginalis* during and after anthesis.
Fig. 3. Floral diagram of *Monochoria.*
Figs. 4 & 5. Two kinds of flowers of *M. vaginalis* (diagramatic).
A. The flowers.
B. The flowers with the sterile stamens and perianth removed.
C. The fertile stamens.

Fig. 6.

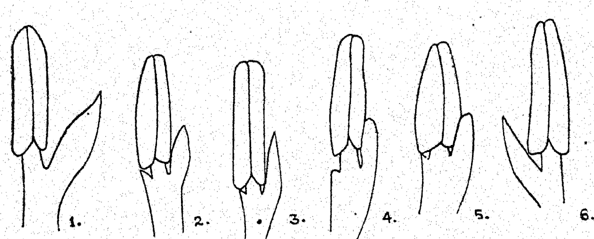
Series. A.



Series. B.



Series. C.



M.O.T. Iyengar del.

Fig. 6. Series A. Fertile stamens of *Monochoria hastaefolia* showing variations in the stamens bending to the left. Note that the spurs on the left are always the bigger.

Series B. Stamens of the same flower bending to the right,—right side spurs always the bigger.

Series C. Fertile stamens while in bud. Note the thick and blunt spurs.

Plate I. Flowering stems of *Monochoria hastaefolia* showing the process of bending of the peduncle after anthesis.

with the pollen of the previous flower comes in contact with the stigma of the second flower. Insects generally visiting the flowers of *M. hastaefolia* are some bees like *Vespa cincta* Fabr., *Xylocopa sp.* (*tenuiscapa* Fabr, ?) and also by *Apis florea* Fabr. The flowers stand vertically and the bee hovering round catches hold of the anterior yellow stamens with its fore and mid-legs and hangs therefrom while sucking up the nectar. While doing so the first two segments of the abdomen and even parts of the thorax come in contact with the anther on one side and the stigma on the other.

The flowers of *Monochoria vaginalis* are chiefly visited by *Apis indica* Fabr. which collects the pollen from the sterile anthers with its fore and mid-legs. The bee collects the pollen from only the five sterile stamens. I have never seen any of them collecting the pollen from the posterior blue stamen. The bee first alights at the mouth of the flower and then walks in towards the anterior yellow stamens. While doing so its two hind legs walk upon the stigma on the one side and the fertile stamen on the other. From numerous specimens caught visiting these flowers it was found that the femur, tibia and the first tarsus were covered over with a dense matting of pollen, the accumulation perhaps of several months. The hairs on the hind legs together with the stigmatic fluid with which it frequently gets smeared over, keep this matting intact. The way in which cross-pollination is effected by this bee in *M. vaginalis* is evident.

No reference has been on record regarding this peculiarity of the flowers of *Monochoria*. The Flora of British India says nothing more than "stamens six, one usually largest, with filament toothed on one side. Anthers basifixed, slits terminal" Engler and Prantl in *Die Naturlichen Pflanzenfamilien* say "Stf. anther Basis spornartig verbreitet." An old paper by Dr. John Kirk, M. D. under the misleading heading of "On the dimorphism in the flowers of *Monochoria vaginalis*. Presl" (Journal and Proceedings of the Linnean society, Vol. VIII, 1865) states nothing more than the occurrence of cleistogamous flowers in this species which is not obvious in the Indian and Australian specimens.

Although there has been no record of the floral dimorphism in *Monochoria*, floral dimorphism of a somewhat similar type has been known in a few instances. In some species of *Cassia* (*Caesalpiniaceae*) the three large posterior stamens bend to one side and the style bends in the opposite direction. In some flowers two of the stamens bend to one side while the style and the other stamen bend to the other side. This is neither definite nor regular. But the nearest approach to the present type of dimorphism on record is that of the flowers of

Heteranthera reniformis Ruiz et Pav., (*Pontederiaceae*), "Herm. Müller says that this species possesses two kinds of stamens one long one with pale blue anthers and two short ones with yellow pollen. When the small white flower opens, the former bends to the left and the style to the right.* " This plant being so closely allied to *Monochoria* and showing a more or less identical phenomenon, it may not be wrong to presume that the one kind of flower here mentioned is as common as the other kind, namely, that with the fertile stamen bending to the right and the style to the left; it is very likely that this plant has also a similar floral dimorphism.

Investigations have failed to show the true factors responsible for the bending of the style to one side and of the stamen to the other, in the flowers of *Monochoria*. The floral bud is quite symmetrical, the posterior stamen being quite median and the pistil quite central in position. The bending of the posterior stamen and the style takes place 12 to 6 hours prior to the opening of the flower and when the flower opens there is no optical symmetry in the disposition of the floral organs. Some clue is however available to explain the bending of the stamens. The fertile stamen of *M. hastaefolia* has one or two lateral spurs from the filament and these are never equal in size. Examination of a very large number of flowers has shown that the side to which the stamen bends invariably corresponds to the side on which the staminal spur is present, and if there are two spurs, to the side of the bigger spur; so that even in a detached stamen it is possible to say as to which side it was bent in the flower. Fig. 6. series B. show stamens which bend to the right and series A. in which the bending is to the left. In more developed forms the smaller spur is fully suppressed as in the extreme forms A. 1 and 5. In the flowers of *Monochoria vaginalis* the stamen bends to the side on which the filament has a large spur. But it has only one outgrowth the smaller one being always absent and in this respect this species is more developed than *M. hastaefolia*. (Fig. 4. C. and Fig. 5 C.)

Although the presence of the spur is correlated with the bending of the stamen, the manner in which the bending is caused is still beyond conjecture. In the bud when the flower is quite symmetrical the outgrowths are thick and blunt as in Fig. 6 series C. In the bud about to open in which the stamen has already bent the same spur is thin, long and tapering (Fig. 6 series A. and B.) As this change in the appearance of the spur and the bending of the stamen take place simultaneously, it is presumed that the former is probably responsible for the

* (Quoted from Knuth's Handbook of flower-pollination Vol. III, pp. 475-6.)

bending of the stamen. The bending may be brought about by the constriction on the side of the spur as a result of its attenuation.

But while the bending of the stamen could be explained, there is nothing apparently to account for the bending of the style to the side away from that of the stamen.

The flowers of *M. hastaefolia* open at about 7 A.M. and close up at about 1 P.M. When closing, the perianth lobes twist together in a corkscrew fashion (Plate I) and all the floral parts are enclosed together. This is significant in that it may effect self-pollination in cases where cross-pollination was not secured. Some flowers enclosed in paper-bags and kept covered from insects, were found to mature and form fruits. This shows that self-pollination is effected when cross-pollination fails. *M. vaginalis* has shorter lived flowers; the perianth lobes close up as in the case of *M. hastaefolia* but they do not twist.

During anthesis, the inflorescence is erect but when all the flowers have opened, the top of the inflorescence bends down as in Plate I. In the case of *M. vaginalis* the young fruits get submerged in the water as a result of the bending of the peduncle and also to some extent of the stem (Figs. 1. & 2). This bending occurs even when a few flowers are yet to open. This phenomenon is common with other hydrophytes like *Limnanthemum indicum*, *Eichhornia speciosa* and *Nymphaea* in which after flowering, the peduncles curve and the young fruits are submerged under water.

I am indebted to Mr. M. J. Narasimhan of the Mysore Agricultural Department for the photograph of plate II.

SOME CRITICISMS ON MASON'S METHOD OF DETERMINING DIRECTLY THE PHYSIOLOGICAL HUMIDITY OF THE SOIL

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The following criticisms are made on the basis of experiments done in order to see whether Mason's method of determining the physiological humidity of the soil would be of any use in the investigation of drought resistance of plants carried on at the Agricultural College, Poona. Mason's method appeared under his own name in the West Indian Bulletin, Vol. XIX, No. 2 of March, 1922. It was a simple method as will be seen later and naturally attracted the attention of the writer.

The following is a brief description of

Mason's Method.

This method consisted in using hard-leaded pencils to absorb water from the soil for a definite period and the weight of the absorbed moisture being taken to be the index to the water supplying power of the soil. This method was a modification of that of Livingston and Koketsu*, who used artificial roots made of porous porcelain and found that they were of some satisfaction and yet regarded the apparatus and the methods to be exceedingly crude. The porcelain roots were temporarily called soil points. They were hollow unglazed cylinders 13·5 c.m. long and 2·5 c.m. in outside diameter, shaped towards one end into a tapering cone 5·5 c.m. long. The wall of the cylinder was about 3 mm. thick. A portion of the surface nearest to the pointed end of the porcelain cylinder was water-proofed as was also the entire cylindrical surface and a portion of the broad end of the cone, leaving nearly 10 sq. cms. of surface without being water-proofed. Mason carried this investigation further using hard-leaded pencils in place of porcelain roots with a view to simplify and introduce a modification of detail. He used "Kohinoor 6 H" pencils (made by L. and C. Hardtmuth, Vienna) in his experiments. He says "A very constant absorbing area was readily obtainable by

* Soil Science, Vol. IX of 1920, p. 469.

using an ordinary mechanical pencil sharpener, the rest of the surface except the unsharpened end which was sealed with paraffin wax, remaining water-proofed by the varnish of the pencil." A number of such pencils or soil points after standardisation and sharpening were weighed and inserted in the soil for a definite period, the hard lead of the pencil assisting in the penetration of the conical absorbing surface. As the absorbing surface came to rest, contact between it and the soil was attained in a manner somewhat similar to that between a growing root and the surrounding soil. The compression of the soil immediately about the absorbing surface should approximate as closely as possible to that due to the root and it should not differ from one determination to another. Care was accordingly exercised to insert the soil points slowly into the soil otherwise the rate of water transmission may be appreciably accelerated. At the end of the definite period, the soil points were withdrawn and, after careful removal of the adhering soil by a cloth, reweighed. The gain in weight was taken to be an index to the water supplying power of the soil. A celluloid case was used by Livingston and Koketsu to prevent the water loss while the soil points were being taken from the soil to the balance. This was considered unnecessary by Mason with the laboratory conditions under which this work was carried out.

The above method as described by Mason was followed in all its details in the experiments that were conducted here. These were done under laboratory conditions in the months of July and August, 1922. A clayey loam soil first air dried and then passed through a 2 mm. sieve was used in all the experiments. Earthen pots were filled with this soil in uniformly compressed layers. The soil was moistened thoroughly by means of a water-can and left in that condition for four days, a sufficiently long period for the uniform distribution of moisture. The "Kohinoor 6 H" pencils recommended by Mason were used along with others. The balance was a very accurate one, manufactured by Bunge.

Results

(1) *Imbibitional forces of the wood* :—

(*a*) The moisture absorbed by the soil points made of "6 H. Kohinoor" pencils varied from 11 to 39 m.gms. in one experiment and in another 14 to 33 m. gms. In the first instance they were left in the soil for three hours and in the second for two hours and twenty minutes.

(*b*) In another set of three experiments four pencils were used of which three were Kohinoors of different hardnesses and the fourth

was an ordinary one. The moisture absorbed by these in different periods are given in the following table :—

Hours.	Minutes.	Kohinoor.			Ordinary.
		6 H.	4 H.	H	
2	26	16 m.gms.	12 m.gms.	11 m.gms.	...
3	0	...	10 ,,	2 ,,	7 m.gms.
4	0	14 m.gms.	2 ,,	19 ,,	6 ,,

In both the above cases the results varied without any definite relation. This shows that the wood used for these pencils does not give consistent results in different periods with different types of pencils and so no definite conclusive results can be obtained from their use. These do not show that the material of any one pencil behaves similarly in its different parts as to its absorbing power. Standardization will not be of any use since the same portion of the pencil is not used more than once.

(2) *Absorption through the varnished part* :—

Mason thought that the varnished portion of the pencil was water proof and the upper end being paraffined, the only absorption possible was from the sharpened surface. But the varnished surface does absorb moisture as will be evident from the results of the following experiment :—

EXPERIMENT :—

Eight pencils were taken and both the ends of each were paraffined. They were then kept horizontally in moist soil so that the middle two inch portion of each was surrounded by the soil. The amount of moisture absorbed in three hours was as follows :—

Order in which weighed.	1	2	3	4	5	6	7	8
Kohinoors.	6 H	6 H	6 H	6 H	6 H	4 H	H	4 H
Water absorbed in m.gms.	12	12	5	5	2	7	·6	·4

The weighings were done in the order in which they are given above. The low values obtained in 5, 7 and 8 are probably due to the factor mentioned in the next para.

(3) *Loss before weighing* :—

Mason remarks that a celluloid case is unnecessary to prevent water loss under laboratory conditions, but the loss of moisture from

the absorbing cone of the pencil during ten minutes after withdrawal from the soil, though enclosed in a card-board box, is considerable. In twelve determinations it varied from nil to six m.gms., usually two or three m.gms., when the total amount of moisture absorbed was found to vary from ·4 m.gms. to 12 m.gms. It is necessary, therefore, to take every precaution to prevent this loss by means of a celluloid case as Livingston did or through some other device.

(4) *Soil adhesion* :—

The method of removing the adhered soil my means of a cloth after withdrawal of the soil-point does not deprive it of all the soil particles unless it is given some time to dry. But no time can be allowed as there is the likelihood of losing some of the absorbed moisture.

(5) *Moisture-free condition of the soil point* :—

Livingston in his experiments used porcelain soil-points which were rendered-moisture free by subjecting them to a temperature between 102°C and 105 °C for 24 hours. Mason has not treated the soil points (pencils) in the above manner. The writer has found a loss of nearly 5 per cent. of the weight of the pencil by subjecting a pencil to a temperature of 100 °C for five hours. The pencil was then kept in a cardboard box for two days and on reweighing showed an increase of 4·6 per cent. of the original weight of the pencil. The amount of moisture which is normally present in the pencil is a factor that might vary under different atmospheric conditions. So the absorbing capacity of the soil points might also change accordingly. This factor, however, does not arise in Livingston's porcelain soil points.

(6) *Less absorbing surface* :—

In the case of pencil soil points the absorbing surface is small, being only 2 sq. c.ms., (*Cf.* Livingston's porcelain soil points where it is 10 sq. cms.). This, along with the other foregoing undeterminable errors, is likely to give faulty readings.

In conclusion I must say that Mason's modification of the "soil point" method does not in my experience give consistent results, and is therefore not useful for exact, accurate and minute determinations absolutely necessary in experiments for determining the physiological humidity of the soil.

THE FLORA OF SIND.

BY

T. S. SABNIS, B.A., M.Sc.

Continued from the Pages 153.

VII. Capparidaceae.

1. CLEOME *L.*

1. **Cleome papillosa** *Steud. Nomen. ed. 2, I (1840) 382.* Loc. Karachi: "Thano-Bula-Khan" (9). Larkana: Laki, foot of the Hill (Sab. 611:). (9 without locality).

Distribution.—Rajputana, Arabia, Abyssinia, Nubia, Kordofan, Fl. and Fr.: October and November.

2. **Cleome quinquenervia** *DC. Prodr' I (1824) 139.* Loc.—Larkana: "Laki" (9); (9 without locality).

District: Persia, Afghanistan, Arabia.

3. **Cleome Stocks ana** *Boiss. Diag. ser. 2 (1853) fosc. I, 47.* Loc.—"Boogta Hills" (9). "Laki" (9).

Distribution.—Baluchistan.

4. **Cleome brachycarpa** *Vahl ex Dc. Prodr. I (1824) 240.*

Vern. Name: *Kasturi.* Loc: Karachi: "Karachi" (9), Ticehurst (32281!); Larkana Laki, foot of the Hill (Sab. B295!) Sukkur: Sukkur (9). Hyderabad, Hyderabad, Ganja Hill (Sab. B989!) Thar and Parkar: Mirpurkhas (Sab. B 946!, B. 1036) "Boogta Hills" (9) (9 without locality).

Distribution.—Punjab Plains, Westward to Arabia, Abyssinia and N. Africa. Fl. and Fr:—Oct. and Nov.

Cleome brachycarpa var. longepetiolate var. nov,

Leaves 3-5 foliolate; petioles up to 3-5 cm. Seeds notched and reticulated.

Loc.:—Karachi: Karachi (Ticehurst 28141) Larkana; Laki, foot of the hill (Sab B621!). Fl. and Fr.—Aug.—Oct.

5. **Cleome burmanni** *Wt. and Arn. Prodr (1834) 22.* Loc.:—Hyderabad: "Hyderabad" (9).

6. **Clemoe viscosa** *L. Sp. Pl (1753) 672.* Loc.:—Larkana: Larkana. fields (Sab. B. 92!). Thar & Parkar:

Nasarpur (Sab. B 1139 !), Mirpurkhas (Sab. B. 682 ! , B947 !), Sanghar (Sab. B767 !).

Distribution :—Throughout the tropical regions of the world. Fl. and Fr :—Oct. and Nov.

2. GYNANDROPSIS *DC.*

1. **Gynandropsis pentaphylla** *Dc. Prodr. I. (1824) 238.* Loc :— Karachi : Karachi (Ticehurst 28151 !). Nawabshah : Pad Idan (Sab. B508 !). Khairpur : Khairpur sandy plains (Sab. B232 !)

Distribution :—A common weed in all tropical countries. Fl. and Fr.—Oct.

3. DIPTERYGIUM *Decne.*

1. **Dipterygium glaucum** *Decne. in Ann. Sc. Nat. Ser 2, IV (1835) 67.* Loc :—Thar and Parkar : Umerkot,—sandy plains (Sab. B.945 !), sand dunes (Sab. B- 1012 !). "Near Jacobabad " (9).

Distribution :—N. E. Africa, Arabia. Fl. and Fr.—Nov.

4 CADABA *Forsk.*

1. **Cadaba farinosa** *Forsk. Fl. Aegypt.—Arab (1775) 68.* (9 without locality).

Distribution. :—Trop. Africa, Arabia.

2. **Cadaba heterotricha** *Stocks in Hook. I con. Pl. IX (1852) t. 839.* Loc. : Karachi : " On rocks near Cape Monze " (9).

5 CAPPARIS *L.*

1. **Capparis spinosa** *L. Sp. Pl. (1753) 503.* Loc. : Karachi : Soorjana Hills 1800 feet. (Ticehurst 30885 !) Larkana : Larkana, coloured soil (Sab. B.454 ! B463 !) " Kirthar Range " (9) Sukkur : Sukkur, coloured soil (Sab. B.542 !) ; " Ruk Junction " (9)

Distribution. : Mediterranean region, N. Africa, Asia, Australia. Fl. and Fr. : Aug-Nov.

2. **Capparis decidua** *Pab. in Engl. & Prantl, Pflanzenf. III—2, 231* Loc. : Karachi : Magho Pir (Sab. B206 !). Larkana. Larkana, coloured soil (Sab. 443 !); Sehwan, sand dunes (Sab. B665 !), coloured soil (Sab. B. 351, B. 592!); Laki, foot of the Hill (Sab. B. 1 !, B. 280 !). Nawabshah : Pad Idan (Sab. B. 504!, B. 571 !, B. 573!). Khairpur: Mir's forest (Sab. B. 323!). Hyderabad: Phuleli canal banks (Sab. B. 188!, B189 !) ; Koari, Indus banks (Sab. B388 !). Sukkur: Sukkur, coloured soil (Sab. B. 543 !). Thar & Parkar : Nasarpur, sandy plains (Sab. B1046 !) ; Mirpurkhas, water course (Sab. B850 !, B874 !); Sanghar (Sab. B768 !); Umerkot, sandy plains (Sab. B. 934 !), (9 without locality).

Distribution :—Trop. Africa, Arabia, India. Fl. and Fr :—Oct. and Nov.

Note.—The most common plant on coloured soil and sandy plains, associated with *Zizyphus rotundifoia* Lam, *Leptadenia spartium* Wt. and *Aerua* Forsk.

3. **Capparis horrida** *L. F. Suppl.* (1781) 264. Loc : Nawabshah : Pad. Idan (Sab. B. 561 !) ;

Distribution. : Gangetic plain ; Western Peninsula, Chittagong to Pegu ; Ceylon ; Java ; Philippines.

VIII. Resedaceae.

1. RESEDA L.

1. **Reseda pruinosa** *Delile, Flor. Aegypt. Illustr.* (1812) 63. Loc. Larkana : Laki, foot of the Hill (Sab. B. 125 !) " Boogta Hills " (9) " Bullo Khan " (9). (9 without locality).

Distribution :— Eastward to Egypt. Fl. :—Oct.

2. **Reseda Aucheri** *Boiss. Diag. Ser.* 1 (1842) *fasc* I, 5. (9 without locality).

Distribution :— Eastwards to Persia.

2. OCHRADENUS *Delile.*

1. **Ochradenus baccatus** *Delile, Flor. d'Egypte,* (*1812*) *236, 31.* Loc. : Karachi : Soorjana Hills 1800 ft. (Ticehurst 30881 !), (9). Thar & Parkar : Nasarpur, sandy plains (Sab. B. 1052 !, R. 1060, B. 1062 !)

Distribution :— Westwards to Syria and Egypt. Fl. and Fr. : Aug.—Nov.

IX. Violaceae.

1. VIOLA. *L.*

1. **Viola Stocksii** *Boiss. Fl. Orient. I.* (1867) 453.
Loc. : " Margalli " Moosa Khail " (9).

Distribution :— Baluchistan Afghanistan.

X. Polygalaceae.

1. POLYGALA *L.*

1. **Polygala erioptera** *DC. Prodr.* I (1824) 326. Loc. : Karachi : " Jamadar ka Landa " (9) ; " Karachi " (9). Thar & Parkar : Nasarpur, clayey soil (Sab. B 1053 !, B 1127 !) ; Jamesabad, fields (Sab. B. 1092 !).

Distrib. : Africa, Arabia and Tropical Asia. Fl. & Fr. : November.

2. **Polygala irregularis** *Boiss. Diag. ser.* 1 (1842) *fasc.* I, 8. (9 withour locality).

Distrib. : Kordafan, Arabia, Baluchistan.

(*To be continued*).

NOTES

A Long-lost Liverwort

BY SHIV RAM KASHYAP

In the Posthumous Papers of Griffith (Notulae ad Plantas Asiaticas, Part II, 1849) there occurs the description (along with figure) of a curious liverwort under the name *Monoselenium tenerum*. Under habitat are the words "In agris arenosis Cheikwar Suddya prope, regionis Assamicae alt, nuperius reperi copiose in sylvis humidis Tingrei". The description and the figures, however, are not quite adequate to put the plant in its proper place, and apparently, according to the enquiries of Goebel (*vide* Paper mentioned below), there is no specimen of the plant in the herbarium either at Kew or Calcutta, which may be examined for the purpose. Writers on Liverworts have therefore been puzzled about the proper place of this genus. Schiffner (in Engler and Prantl) doubtfully refers it to *Cyathodium*. Stephani (in "Species hepaticarum") also refers it to the same genus and the species doubtfully to *C. aureonitens* (Griff.) Schiffn. About ten years ago Goebel published a very interesting paper (Monoselenium tenerum Griffith· Flora 1910) in which he fully described a plant obtained from Canton and in which after a thorough investigation he showed that his plant was identical with Griffith's *Monoselenium tenerum*. In a note he adds that the only way to find Griffith's plant now is to look for it in the place where Griffith originally got it and if it happened to be identical with the plant described in his paper the fact would add one more argument to his conclusion. He says that Captain, (now Colonel), Gage, the Director of the Botanical Garden at Calcutta, has kindly consented to keep a look out for the plant. I am not aware if the plant has been recorded from India by Colonel Gage or any body else so far.

In May 1920 my friend and former pupil Mr. Sunder Lal Hora working in the Zoological Survey of India, sent me a collection of liverworts from Assam. Among them I found one from the Presidency garden at Manipur which was identical with the plant from Canton described by Goebel. Professor Goebel had kindly sent me some specimens of his plant and it agreed with them perfectly. I sent a small bit of my dried material to him also at that time and he agrees as to the identity of the two plants. Thus after more than eighty years Griffith's plant has again been found in Assam. It may be mentioned that Suddya (or Sadiya) and Tingrei (or Tingrai) are both in the Lakhimpur district of Assam, while Manipur is lower down to the south.

CURRENT LITERATURE.

Books

Willis, J. C. Age and Area, a study in Geographical Distribution and Origin of Species, *Cambridge, The University Press, pp. 251 with many diagrams, £ 0-14-0.*

It is always a good thing when the author of a new theory brings it out in book form. With papers appearing in different journals, some of which may not be readily accessible, points and arguments are apt to be missed and an incomplete picture obtained. Moreover the writing of a book compels the author to marshall his facts and deductions with greater care and to produce an orderly sequence of thought. For these reasons the book under review is to be heartily welcomed. Dr. Willis' theory, first enunciated about seven years ago, has attracted much attention in botanical circles in England, and is, through this book, now available in a complete and convenient form to students in India.

The theory was founded on the results of a study of the distribution of endemics and other species, first in Ceylon then in New Zealand and other countries. Dr. Willis found in Ceylon that the area covered by an endemic species is almost invariably much less than that of one which also occurs outside. Further taking the areas covered by nearly allied species he found that (barring exceptional cases and taking several species together) the endemic species can be placed in the order of the areas covered, the smallest number covering the largest areas, and the largest number the smallest. While with species which occur also outside the island it is the other way, about a third of such wides covering the whole island, and a few only being found in small areas. Moreover those with widest distribution outside have also the widest distribution inside the island. This, he argues, shows that the endemic species are not better fitted to the local conditions than the widely spread ones, and are therefore not products of adaptation brought about by Natural Selection : but that it is the age of a species which is the chief factor in determining the area over which it has spread.

In Chapter VII he gives an account of the endemic and other species in New Zealand and its neighbouring islands, and shows that their distribution is as might be predicted from his Age and Area theory, *viz.* the species common to the main islands and the smaller ones, are the most widely distributed on the main island (because they are the oldest). Endemics are commonest where there are most wides, not where there are fewest, as he argues would be the case if the endemics were species in the process of dying out. In Chapter VIII the application of the theory to the results of invasion of plants is discussed. New species (endemics) will be found mostly near the point of entrance. Chapter IX is devoted mainly to meeting criticism of the theory and deserves careful reading.

The remainder (Part II) of the book deals with the application of the theory to other countries, and to animals: and contains contributions by other botanists. Mr. H. B. Guppy, who has done important work on distribution on the Pacific Coast, and enunciated a theory of an original worldwide distribution of primitive types (see this journal Vol. I, p. 61) writes chapter X, on the Position of the Theory. He writes sympathetically but his chapter does not contribute much to its support. Another chapter is by Dr. James Small, who has made a special study of the Compositae, and now shows in detail how the theory is borne out by the distribution and relative ages of the various tribes and genera as determined by him on purely morphological considerations. Though Mr. Reid writes a good chapter (XIV) on the Palaeobotanical Evidence, it cannot be denied that here the case is weakest. For there are too many instances of undoubted relics occupying (endemic in) small areas. The remaining chapters are devoted to discussions of endemism and the distribution of species and genera, of the similarity of the numerical results as shown in the "hollow curve", and of the bearing of these facts on an explanation of the origin of species. Dr. Willis is in favour, it is clear, of evolution by mutation rather than by the accumulation of small differences by natural selection, and a chapter is contributed by Hugo de Vries the chief exponent of the mutation theory. The chapter by the author on Distribution in general closes the book.

While opinions differ as to the relative importance of the facts quoted by Dr. Willis, and on the validity of his conclusions, without doubt the theory is a great contribution to the study of evolution, and one which no biologist can afford to pass by. The book deserves, reading and re-reading, and may be recommended specially for students of honours degrees in this country and of course all university teachers. The former should however be warned not to be led by the positiveness of the author's assertions and the confidence of his writing to regard this as the last word on the subject. There are many things difficult entirely to accept—Dr. Willis for instance would almost have one believe that species do not die out, and that therefore we should be able to trace the immediate ancestors of existing species among others also still existing. To a certain extent the theory is obvious and acceptable. It is Dr. Willis' insistence on 'Age and Area' being the sole or at least the paramount factor in distribution that is difficult to accept.

The book is turned out, it need hardly be said, with the uniform excellence of the Cambridge University Press.

P.F.F.

Tansley, A. G., M.A., F.R.S. The Elements of Plant Biology, *London, George Allen and Unwin, Ltd. £ 0-10-6*

Text books on Biology are so numerous that it seemed strange at first sight that so distinguished a botanist as Mr. Tansley should find it worth while to add yet another, but a further acquaintance with the contents has shown that whatever may be the worth to him (and we hope it will be as much as the book deserves) there can be no question of the effort being worth making on behalf of the general body of students the book is intended for. For this text-book is no dishing up of old facts and ideas, but a new creation,

something far ahead of the ordinary "Elementary Biology". After a brief introduction to the differences between plants and animals, and to the various types of plants, the student is shown the nature of the different organic substances which compose the plant body. The mysteries of protoplasm and its activities, even the ingestion by an Amoeba of a Diatom and the ejection of its shell, are shown to be explicable by the chemical and physico-chemical properties of colloid-gels and sols.

This important basic study occupies two chapters (40 pages), and is followed by one on the vital functions. In Chapters VI and VII are described the cell and its division, with concluding paragraphs on turgor and wilting, and the activities of the green cell. Chapters VII to XI are devoted to the various classes of colourless plants, yeast, bacteria, mucor, and parasitic fungi. Ch. XII deals with differentiation of structure and the evolution of sex as illustrated in the green and the brown algae. In Chapter XIV we learn about liverworts, mosses and ferns, which are shown to be progressively more perfectly adapted to terrestrial conditions. The next ten chapters (135 pages) deal with the structure of phanerogams, and in Chapter XXIV is a most valuable "conclusion", in which changes in the constitution of the protoplasm are shown to be of necessity the ultimate causes of all specific differences.

At the close of each chapter are given directions for practical work, as done at Cambridge, which the teacher in India will probably find of considerable help.

The book is essentially modern. The points of view are those of to-day. It abounds in statements and arguments which are based on recent researches. It is therefore one strongly to be recommended for all biological students, whether of medicine or botany, and many who have passed the student stage will find in its pages much that is both interesting and inspiring.

P.F.F.

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ON THE THEORETICAL SIGNIFICANCE OF CERTAIN SO-CALLED "ABNORMALITIES" IN THE SPORANGIOPHORES OF THE PSILOTACEAE

By B. Sahni, M.A., M.Sc., Ph.D.
President, Indian Botanical Society.

(*With Three Figures in the Text.*)

Except for the classical instance of the conifers, perhaps, in no other group of plants have "abnormalities" played such an important rôle in phylogenetic discussions as they have in the Psilotales. The theory that this apparently decadent group is closely related to the long extinct race of the Sphenophyllales[1] depended largely for support upon cases of repeated forking in the so-called "sporophylls", which were closely compared with those of *Sphenophyllum* and *Cheirostrobus*. Indeed some morphologists were so deeply impressed by the resemblance—and it was difficult to expect a more striking resemblance between plants so widely separated in time—that they did not hesitate to group the two phyla together.[2]

On the other hand, there was the alternative view, that the fertile appendages of *Psilotum* and *Tmesipteris* are not sporophylls, but rather of the nature of shoots, bearing a variable number of sporangia and sterile lobes interpreted as leaves.[3] This view found support, among other points, in an "abnormality" described by Mrs. Thoday (Miss M. G. Sykes) which consisted of a branched axis bearing several leaf-like lobes and sporangial clusters in different planes. The author rightly said that a structure of this type could not readily be taken for a modified leaf, but that it might well be described as a branched leaf-bearing sporangiferous shoot.[4]

[1] An affinity first suggested by Dr. Scott (1897) but apparently no longer upheld by him (see Scott 1922, p. 13 of reprint); Scott (1907), pp. 163-66; Thomas (1902); Bower (1908) p. 398.

[2] Thomas (1902); Bower (1908), p. 398.

[3] A view advocated, among others, by Strasburger (1873), p. 91; Goebel (1881); Bertrand (1881); Sykes (1908), p. 82.

[4] Sykes (1908 A), p. 526.

Within the last few years the brilliant discoveries of Kidston and Lang,[1] apart from elucidating other and more important issues, have thrown a considerable weight of evidence in favour of the axial theory. I think we are justified in calling this a rather unexpected turn of events, for the sporophyll theory appeared to rest on a sure foundation. But now it seems as if this favourite comparison will have to be abandoned. Strange as it may appear, of all known plants, the closest resemblances of the modern Psilotaceae are with the early Devonian Psilophytales, the most ancient land plants whose anatomy is known. Kidston and Lang have shown that not only do the Psilotaceae bear striking resemblances with the fossil group so far as the vegetative organs are concerned, but that even in the fructifications a reliable basis for comparison is supplied by the repeatedly forked aerial shoots of the Rhyniaceae with their large terminal sporangia capable of sharing the dichotomy of the axis. According to these authors, "the sporangiophores would appear to represent the last persisting remains of the original leafless branch systems of the

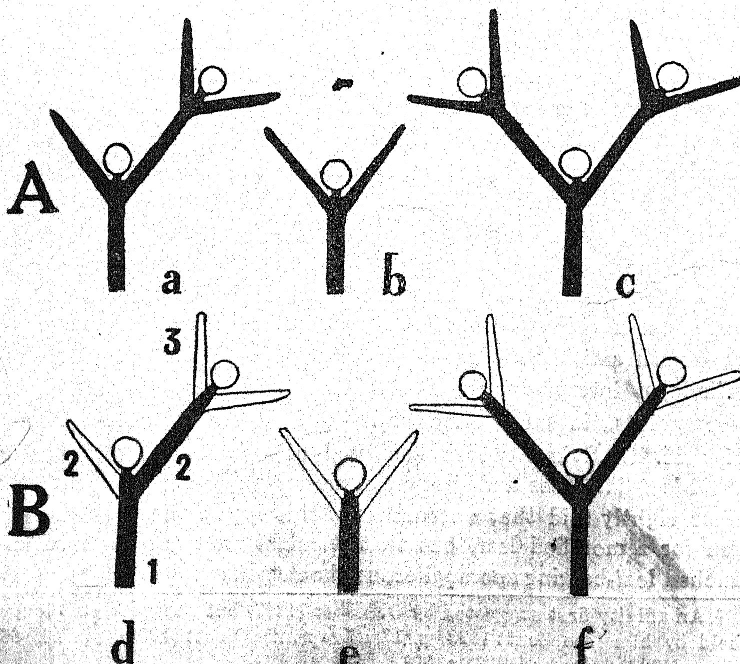

FIG. 1.

[1] Kidston and Lang (1917-21), pt. IV, p. 850.

Rhyniaceae".[1] And the exceptionally frequent occurrence of repeated forking in the sporangiophores of the Psilotaceae then appears in a fresh light, as a reminiscence of an age even earlier than that of the Sphenophylls, when it was an established feature of the whole aerial shoot.

Examined a little more closely the axial theory resolves itself into two possible alternatives; these are illustrated diagrammatically in fig. 1, A, B. The difference between the two views rests solely upon the interpretation of the leaf-like lobes, whether as axial (Fig. 1 A) or as foliar organs (Fig. 1 B). But an examination of a case like that shown in fig. 1, B d. indicates that the distinction really does not amount to much, for the results of the first dichotomy (2, 2) are homologous, although one of them is developed as a leaf, the other as an axis. One naturally enquires whether we are not after all dealing here with plants in which the differentiation of "leaf" and "stem" has not yet reached a categoric stage.[2]

There is however a danger that in our eagerness to accept the axial theory of the sporangiophore we may be unduly severe on the comparison of the Psilotaceae with the Sphenophyllales. For, if we cannot agree with the "forked sporophyll" theory, there is another aspect of the sporangiophore of the Psilotaceae X which lends countenance to a comparison with the Sphenophyllales ~~which appears to retain for this family a place within the fold~~ of the Articulatae. This aspect is suggested by two abnormalities observed in *Tmesipteris Vieillardi* Dang. (see fig. 2)[3]. see the Corrigenda

The abnormality shown in fig. 2 I, II somewhat resembles in its complexity that described by Mrs. Thoday in *Psilotum triquetrum*[4]. The structure figured in the present paper, while lending itself to a similar interpretation, differs in being branched in a more regular manner. In the first place the whole organ is forked in the same plane as the main stem, but this may very likely be a case of two sporangiophores which have accidentally become fused together by their peduncles. But then one of these sporangiophores (A) is branched in a verticillate manner, a whorl of three sterile lobes being succeeded

[1] Kidston and Lang (1917-21) Part IV, p. 850. These authors have also pointed out the significance, in this connexion, of the peculiar forked axes found in association with *Asteroxylon*; whether their attribution to that genus is finally proved or not, the bearing of the general organization of the Rhyniaceae at least cannot be overlooked.

[2] It is unnecessary here to follow up this rather complicated question which is really outside the scope of this paper and has been ably dealt with by eminent botanists (see Bower (1920), pp. 712, 713; Kidston and Lang (1917-1921), Pt. IV and the literature therein referred to).

[3] Sahni (1922), p. clxxix.

[4] Sykes (1908), p. 525-6.

by a whorl of three sessile sporangia alternating in position with the sterile lobes. The other sporangiophore (B) is almost identical with the first, except that it lacks an inner sterile lobe which if present would be wedged in between the two sporangiophores.

The second abnormality (fig. 2 VII, VIII) was found at the extreme apex of a plant, with the peduncle almost in continuation with the stem, and it seems as if this relatively neutral position has lent somewhat of an additional symmetry to the organ, which in a lateral position would presumably have been zygomorphic, like the "normal" sporangiophore shown in the same figure. The superficial appearance of the synangium of the Psilotaceae as the "ventral lobe" of a "sporophyll" is due to an adaxial bend in the short stalk of the synangium which is thereby tilted into a protected position. In the abnormality before us the synangial stalk has remained practically unbent, so that the synangium appears as a clearly terminal organ. What is more, the two sterile lobes, which are here unusually wide apart, have also come to lie nearly in one and the same plane which, we may note, is roughly perpendicular to that of the "two sporangia" (bilocular synangium). It is not unreasonable to suppose that in a perfectly central position the same structure would have been quite symmetrical along two planes [1].

It will now be evident that the two abnormalities just described, although so different in appearance, are built on the same fundamental plan: both may be described in the same general terms as consisting of axes bearing alternate whorls of sterile lobes and sporangia. In the one case the whorls are trimerous, in the other they are dimerous; in both the sporangia are coalescent, forming synangia.

The question is: Are these verticillate organs merely monstrosities, of no phylogenetic significance, or may we look upon them as reversions to a condition that was "normal" in some archaic group of plants genetically related to the modern Psilotaceae? Great caution is necessary in attempting to draw theoretical conclusions from abnormalities, which as a class have earned some notoriety for being treacherous guides. For this reason, my remarks here are not intended as anything more than a tentative suggestion. But the mere fact that the sporangiophores of the Psilotaceae normally have a zygomorphic symmetry need not stand in the way of their being derived from verticillate organs. After all the "normal" sporangiophores of *Psilotum* and *Tmesipteris* do not differ materially from the structures we are considering, for the want of symmetry may have been

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[1] As shown diagrammatically by Prof. Goebel (1915-18) fig. 1084 IV, p. 1100.

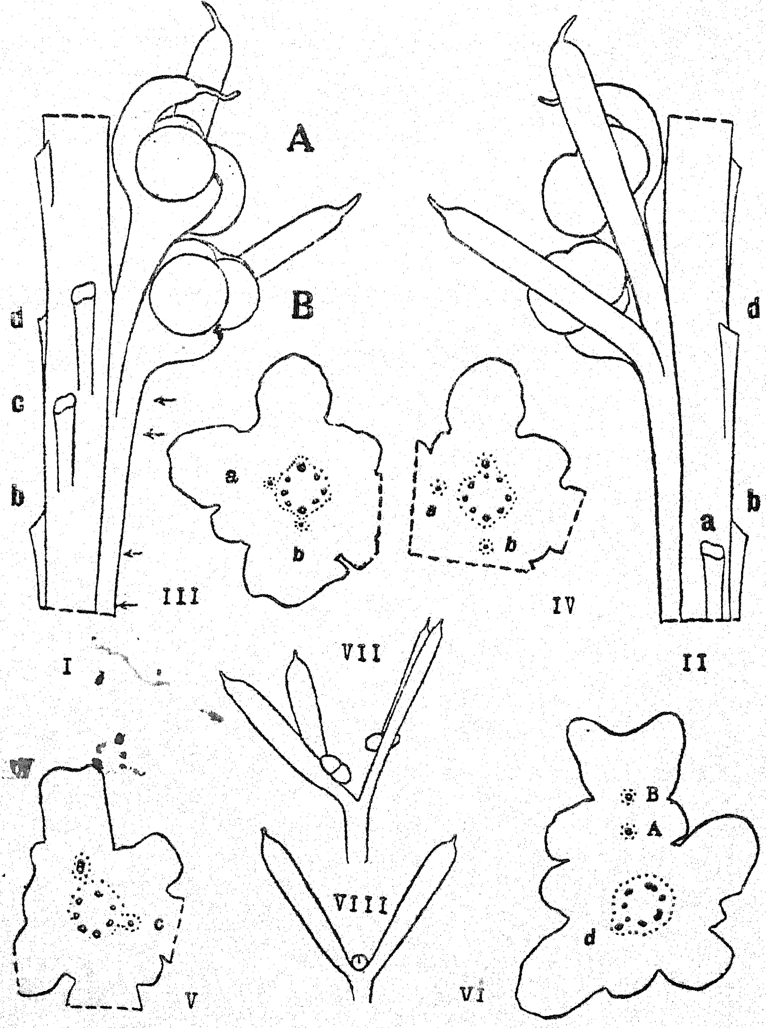

FIG. 2.

Fig. 2.—I, II : different views of the first abnormality. The neighbouring appendages (a, b, c, d) have been removed.

III-VI : serial transverse sections (at the levels indicated by arrows) to show the vascular supply to the normal (a, b, c, d) and abnormal (A, B) appendages. The supply to the latter arises as a single unusually large strand nipped off tangentially from one of the main stelar bundles and soon dividing tangentially into two (VI, A, B). The remnant of the original stelar bundle soon disappears, leaving a gap in its place (V).

VII, VIII : different views of the second abnormality. VII, profile view of abnormal sporangiophore with a normal sporangiophore near it. VIII face view of abnormal sporangiophore.

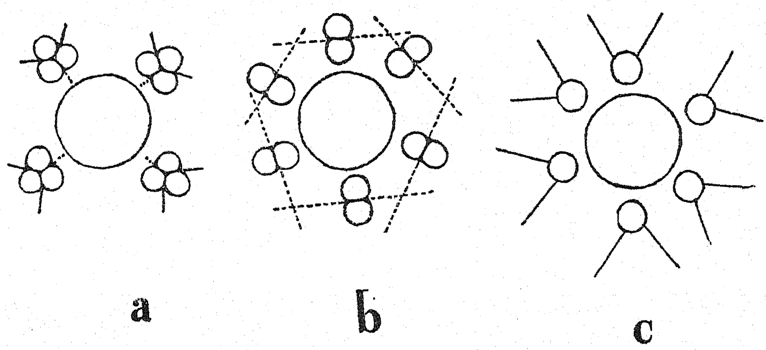

FIG. 3.

dictated by the contingencies of space [1] (see the diagrams in fig. 3). In the case of sessile trimerous sporangiophores placed laterally on a stem (with the short synangial stalk bent adaxially to afford protection to the young synangium) it would be easy to understand the gradual disappearance of the inner sterile lobe (shown dotted in fig. 3 a) wedged in between the synangium and the main stem. Similarly, if we imagine a number of dimerous sporangiophores placed in a crowded manner on the stem (as they usually occur in *Tmesipteris*) the sterile lobes could scarcely occupy a situation more prejudicial to their normal functions than their theoretical tangential position (shown as broken lines in fig. 3 b). On the other hand, a slightly inclined position obviates all overlapping especially as owing to the adaxial bend of the synangial stalk, the synangium leaves the angle between the sterile lobes, which can now lie closer together (fig. 3 c.)

If the conjecture put forward above has any justification, the comparison of the sporangiophores of the Psilotaceae with forked sporophylls, however attractive at one time, becomes more unreal than ever. But at the same time the suggestion of a verticillate organization for their sporangiophores tends to keep up the Sphenophyll alliance, which the Psilotales share with the other Articulatae. Except that they are devoid of sterile lobes, the peltate sporangiophores of the Equisetales and Sphenophyllales may also be described

[1] Perhaps partly also by the unilateral influence of forces like gravity and light, acting upon lateral organs. There is scope here for experimental work on living plants for those who are favourably situated.

as axes branched in a verticillate manner into so many sporangium-tipped segments, which are, however, recurved and coalescent with each other so as to form distal pads [1]. It may be that the whorled arrangement is in origin a sort of condensed repeated dichotomy reminiscent of the condition in the Psilophytales.

It may be added, in the end, that whichever view we may take of the sporangiophores of the Psilotales, there appears to be no escape from the conclusion that even in the derivation of these unquestionably archaic plants reduction has played an important rôle. Prof. A. P. W. Thomas, who has had exceptional opportunities of studying the so-called "abnormalities" of *Tmesipteris*, says [2] "Though we may, in a sense, apply the term abnormality to them, it is in a sense with which nothing of the nature of a pathological variation can be associated............It is probably not going too far when we assert that when [nutritive] conditions are most favourable the sporophylls of *Tmesipteris* normally show a repeated dichotomy."

The abnormalities described in this paper were noticed in some material from New Caledonia kindly handed over to me by Professor R. H. Compton [3] to whom my sincere thanks are due. I am also glad to acknowledge assistance rendered by my wife in drawing the originals of figs. 1 and 3.

DEPARTMENT OF BOTANY,
LUCKNOW UNIVERSITY,
March 20, 1923.

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[1] These pads would then correspond to the synangial stalks of the Psilotales.

[2] Thomas (1902) p. 354; see also Scott (1907) p. 165.

[3] Compton (1922), p. 435. The greater part of the descriptions will shortly be published elsewhere, but these abnormalities appeared to be of sufficient interest to be dealt with in a separate paper.

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NOTE ON SOME ATTACHED FORMS OF ZYGNEMACEAE

Read before the Indian Science Congress Meeting at Madras, January, 1922.

BY

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Members of the Zygnemaceæ are generally found freely floating in water. But a few of them * however have been known to occur attached to submerged stones, logs, etc., by means of rhizoidal outgrowths. Three such cases came under the observation of the author and, as they presented certain interesting features, some of them not recorded before, they are described at some length here below.

A species of *Spirogyra*, a species of *Zygnema* and a species of *Mougeotia* were growing in a tap water fountain in Madras. All the three species were sterile and were never found in a fertile condition though kept under observation for a long time. All the three were growing in an attached condition.

The fountain is built of masonry work and contained water to a depth of 2½-3 feet. There is a bronze statue in the middle. There is a tap at the side of the fountain which supplies it with water. The water is never allowed to dry up in it but is almost always more than three-fourths full. Water is taken out of it daily by the gardeners for watering the plants around. So, what with the flow of the water from the tap and what with the removal of the water from it by the gardeners with their pots, the water in the fountain, is, I should think, fairly well agitated and consequently well aerated. The fountain is quite exposed to the sun. A few plants were growing in it, *Viz.*, *Nymphaēa*, sp. *Hydrilla verticillata*, *Naias* sp, *Chara* sp, and a small plant of *Nipa fruiticans*.

I shall take up the three Algae one by one.

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* West W. & G. S. say that among the Conjugatae, haptera occur only in *Spirogyra* and *Mougeotia*. Evidently they think that it does not occur in *Zygnema*. They say "Organs for attachment are occasionally developed in young plants of *Spirogyra* and *Mougeotia* but have not been noticed in any other genus of the Conjugatæ". [West W. & G. S. ('98, p. 32) and West G. S. ('16, p. 332)]. Delf ('13, p. 366) however refers to the occurrence of rhizoids in *Zygnema*. Fritsch F. E. ('16, p. 146, Fig. 3 B) has figured a rhizoid of *Zygnema* (*Zygogonium*) *ericetorum* (kuetz.) Hansg. Pascher A. ('13, p 4, Figs. D) has given figures of different types of rhizoid formation in a species of *Mougeotia*.

Spirogyra *sp.*

Cells 28 μ thick and about 6 times as long; cells producing rhizoids were nearly twice as long as the ordinary cells of the filament. Cell-wall fairly thick. Chloroplasts three, more or less closely packed.

The Alga was growing on the stalks of water-lily leaves, on the leaves of *Hydrilla*, *Naias*, etc. Disc-like rhizoids or *haptera* were formed from the basal cells of the filament from their ends (Plate I, Figs. 3-8.) The contents of the hapteral cells soon degenerate and disappear. Their cell-walls were invariably very much thicker than those of the other cells of the filament. These disc-like rhizoids were much lobed. Haptera were formed by the other cells of the filament also. If a filament happened to be "lodged" and came into contact with the substratum, haptera were produced from the *sides* of one or more cells of the filament in contact with the substratum. (Plate I, Figs. 5-8). In most cases where lateral haptera (*i.e.* haptera from the sides of the cells) are formed, the portion of the filament on one side of the hapteral cell dies out and disappears. (Pl. I, 5, 6 and 7). The cell forming the lateral haptera becomes strongly convex on the side producing the rhizoid, and deeply concave on the opposite side so that the two ends of this cell are invariably curved sharply upwards with the result that the "lodged" portion of the filament is thereby made "erect" again. This reminds one of the geotropic response of the stems of higher plants when blown down by wind or rain. Of course the behaviour of the Alga is not due to gravity as it was growing in all kinds of directions—all round the leaf stalk of the water-lily, more or less perpendicularly to its surface.

I searched for the younger stages of the Alga. I found many short filaments with only three or four cells growing attached by means of the terminal hapteral cell. I also found very young filaments just one cell long attached to the substratum by a well formed disc. The chloroplasts were confined to the upper half of the single cell, the lower half being without any chloroplasts. I was not able to get any earlier stage such as the germination of cysts or of zygospores. There were plenty of *Oedogonium* filaments growing on the same leaf stalk. But, then, they had their zoospores which could swim and settle down in numbers on the leaf stalk. But how the *Spirogyra* which does not possess any such motile spores came to settle on these leaf stalks *in such numbers* is not quite clear. Further observation is necessary to elucidate this point.

Zygnema *sp.*

Cell 14 μ thick. Length 1-2½ times the breadth of the cell. Chloroplasts slender, star-shaped, with about 5 radiating arms.

This Alga was growing at the bottom of the fountain in contact with the soil. In the day time it often floated up with some of the soil particles sticking to it. This buoying up is evidently brought about by the accumulation of bubbles of oxygen in its meshes.

Short, knob-like, rhizoidal outgrowths were put out from the sides of some of the cells. These rhizoidal knobs were attached to the particles of soil. The cell walls of these rhizoidal cells were thicker than those of the ordinary cells. The rhizoids were usually unbranched. The author, however came across a rhizoid which had branched dichotomously (Pl. III, Fig. 5). They were often elongate and slightly swollen at the tip (Pl. II, Figs. 1-9). Sometimes they were even cut off by the formation of a cross wall into a separate cell (Pl. II, Figs. 10-13 and Pl. III, Figs. 2, 4 and 5). Frequently two adjacent cells produce these rhizoidal outgrowths side by side, which get much prolonged and club shaped and stand side by side, almost touching one another. (Pl. II, Figs. 14-16 and Pl. III, Figs. 3 and 4). These paired rhizoids resemble very much those of *Mesogerron* Brand, a genus described by Brand F. ('99, p. 181) as one of the Zygnemales*

These two rhizoids look like two big conjugating tubes put out for a kind of lateral conjugation. But in no case was any conjugation observed, though a large number of cases was examined by the author. Moreover, soil particles were adhering to these paired outgrowths showing their rhizoidal nature clearly. And the cell contents as in all rhizoidal cells were often very nearly disorganised (Pl. II, figs. 5, 7, 12, 16). The author found such rhizoidal outgrowths of two adjacent cells in two other species of *Zygnema* also, from Kodaikanal, (Pulneys, South India).

There is another interesting feature about these haptera. The axis of the two chloroplasts (*i.e.*, the line joining them) in the ordinary cells is parallel to the longitudinal axis of the filament. But in the cells producing the rhizoids they place themselves at right angles to the axis of the filament and even partly enter the rhizoidal protuberance (Pl. II, figs. 3, 4, 6, 8, 9, 15 and Pl. III, Figs. 3, 4 and 5). This is rather interesting in view of the fact that a similar orien-

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* The exact position of this genus (*Mesogerron*) is still uncertain, as its sexual reproduction is not known. Brand F. ('99, p. 181) who first described it called it a new genus of the Zygnemales. Wille ('97 and '09), Borge ('13) and Pascher ('13) have followed Brand and placed it tentatively in Zygnemales. But Heering ('14) places it in the Ulotrichales. The author, however, thinks that, in the absence of a knowledge of sexual reproduction in *Mesogerron* this similarity in the formation of the paired rhizoids in the two algæ, *Mesogerron* and *Zygnema*, lends some support to the view of Brand, Wille, Borge and Pascher that *Mesogerron* may be one of the Zygnemales.

tation of the two chloraplasts is usually seen in the male gamete in *Zygnema* when conjugating tubes are put forth during scalariform conjugation [West G. S. ('16, p. 344)].

Mougeotia *sp.*

Cells 12.5—14 μ thick, length 4—10 times the thickness.

This species is rather interesting. It occurs amidst the other epiphytic Algae on the leaf-stalks of the water-lily, *Hydrilla* leaves, etc. It sometimes forms knob-like rhizoids like *Zygnema* (Plate IV, Figs. 11 and 12). But more often the ends of its filaments are curiously coiled spirally, tendril fashion, round filaments of *Spirogyra* or round other filaments of *Mougeotia* itself. (Plate IV, Figs. 8, 9 and 10). The coils may have from ½ to many turns, sometimes as many as six turns even. This coiling I did not observe in the middle of the filament but only at the ends. At first the coils are very wide and loose, but later on they become closer, often very narrow. The first time I met this coiling, I thought that it was an accidental twisting of the filaments when mounting them on the slide. But closer and more extended examination of the material showed that it was a definite feature of the Alga. Short fragmented parts of the filament also exhibited this coiling. (Plate IV, Figs. 2 and 4) and even fragmented single cells of the Alga showed a strong tendency to coil.

West, W. and G. S. ('09, p. 195) have recorded the occurrence of coiled filaments of *Mougeotia* in the plankton of some Scottish Lochs. They say "The curious coiled *Mougeotia* filaments of some of the Scottish Lochs have been referred to. It would appear that the coiling is a limnetic character developed to augment the floating capacity of the filament and the fact of its presence is direct evidence that some of these solitary filaments of *Mougeotia* are adapting themselves to a life in the plankton". West, G. S. ('07-'09, pp. 85 and 87) has also recorded this coiled condition in certain other plankton forms also, (*Anabaena*, *Lyngbia* and *Melosira*). He says "the development of this coiled condition is a limnetic character, and it is certainly of great interest to find this character in so many different species and genera of the phyto-plankton". . . He also says "I am not aware of a definite spiral character such as the one mentioned having been developed by any Algae other than limnetic species". Hodgetts ('20, pp. 521-2) has recorded the coiling of certain individual cells in the middle of the filament of *Spirogyra Colligata*. He does not agree with West's view that the coiling is purely a limnetic character developed to augment the floating capacity of the filament, as he found this *Spirogyra* with the coils "amongst other

filamentous forms at the shallow margin of a pond and generally in less than 12 inches of water". Continuing he says, "Moreover in the present case the coiling was generally limited to a single cell of a filament, and in several cases it was clearly seen that the coiled cells were coiled round another filament of the same species. This can hardly be considered accidental, and it appears that this coiling may be a contact phenomenon serving to grapple the filaments together and thus aiding scalariform conjugation."

I agree with Hodgetts in thinking that the coiling cannot be purely a limnetic character. For I found the *Mougeotia* with the coils amongst the other algal epiphytes on the leaf-stalks of the water-lily and other water plants in the fountain—often coiled round the attached species of *Spirogyra* mentioned above. *It was not found freely floating at all.* If I wanted to collect the Alga, I had only to get some water-lily leaf-stalks with the algal growth on them, and, among the other algal forms, I found this *Mougeotia* invariably, with its ends coiled round them and often round itself.

I also agree with Hodgetts in thinking that the coiling may be a contact phenomenon, but I don't agree with him in thinking that it aids scalariform conjugation. For I found the *Mougeotia* coiling not only round itself but also round filaments of *Spirogyra*. And I found generally only single filaments being enclosed within the coils. Moreover, as I mentioned already, the Alga was found only in a sterile condition, though the coiling was there all the time.

I think therefore that the coiling is purely, at any rate with the present Alga, *an arrangement to secure a proper attachment.* I have already mentioned that small fragmented parts of the filament and even single cells showed very strongly this tendency to coil. Evidently these fragmented filaments and individual cells float away after fragmentation, and, if they come into contact with a proper substratum, they put forth knob like rhizoids, and, if they come into contact with *Spirogyra* or *Mougeotia* filaments, they form the coils of attachment.

After considering the behaviour of the above three forms, *viz.*, *Mougeotia* sp., *Zygnema* sp. and *Spirogyra* sp., I have come to think that the formation of the rhizoids and of the coils is most probably in response to some kind of contact stimulus. Delf, ('13, p. 368) thinks that the rhizoids of *Spirogyra* "are formed primarily as the

result of contact stimulus." I am also inclined to believe that the stimulus which induces the formation of the rhizoidal outgrowths must be in some respects similar to that which induces the formation of the conjugating tubes during scalariform conjugation. In *Zygnema* it is interesting to note that the orientation of the two chloroplasts during the formation of the haptera is the same as that noticed when the conjugation tube is put forth during conjugation. Again, West, W. and G. S. ('98, p. 32) have observed the development of haptera in *Spirogyra* "as a result of the modification of a conjugating-tube protruded by a cell some distance removed from those cells of the filament engaged in conjugation."

There is another very interesting point to be noted in the case of the rhizoid of *Zygnema*. If the rhizoidal cell may be considered to correspond to a conjugating gamete, then the cell which is sometimes cut off towards the end of the rhizoid, (see Pl. II, Figs. 10–13 and Pl. III, Figs. 2, 4 and 5), would correspond to the special cell or gametangium which is cut off in the protuberance of each cojugating cell in *Zygogonium* [as described by De Bary and followed by Rabenhorst ('68), Wille ('97 and '09) and Borge ('13) and recently described in detail by Hodgetts ('18)]. Only in the case of the present alga even the sterile cell (*i.e.* the inner cell of the rhizoid), as in the case of *Sirogonium* and *Temnogametum*, contains full protoplasts with the chloroplasts.

Summary.

Three attached Algae belonging to the Zygnemaceae (*Spirogyra* sp., *Zygnema* sp. and *Mougeotia* sp.) were studied as regards their methods of attachment.

Spirogyra sp. forms a well developed disc-shaped, much-lobed, rhizoidal attachment from the end-cell of its filament and also from the sides of other cells of the filament when they come into contact with the substratum.

Zygnema sp. forms knob-like haptera (or rhizoidal outgrowths) from the side of a single cell in the middle of the filament or sometimes from each of two adjacent cells of the filament.

Mougeotia sp. is most interesting. The end of its filament coils itself spirally round a filament of *Spirogyra* or round another *Mougeotia* filament. This coiling is evidently a method by which it secures an attachment. Knob-like haptera are also formed from the sides of the cells sometimes.

In all these cases the formation of the rhizoidal attachments or the coiling of the filament appears to be the result of some kind of tactile stimulation.

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Explanation of the plates.

Plate I.

Fig. 1. A young *Spirogyra* cell beginning to form a rhizoid.

Fig. 2. Do. later stage. Note lower cell without contents.

Fig. 3. *Spirogyra* filament with terminal rhizoid.

Fig. 4. A terminal hapteral cell.

Fig. 5—7. *Spirogyra* sp. with haptera formed laterally from the basal cell. Note the sharp upward curvature of the hapteral cell on either side of the attachment.

Fig. 8. *Spirogyra* sp. with lateral haptera formed from two adjacent cells. Note the curvature upwards of the free ends of the filament.

Fig. 3, 5 and 8 : × 43. The rest × 272.

Plate II.

Fig. 1, 2. *Zygnema* sp. with terminal rhizoidal cell.

Fig. 3—9. Do. with lateral haptera. Note the orientation of the chloroplasts at right angles to the axis of the filament and even entering the rhizoidal outgrowth in Figs. 3, 4, 6, 8 and 9.

Fig. 10—13. *Zygnema* sp. Rhizoidal cell cut off by a cross wall.

Fig. 14—16. Formation of rhizoids from two adjacent cells.

Fig. 17. Do. from three adjacent cells.

All × 210.

Plate III.

Fig. 1. *Zygnema* sp. Two cells of a filament.

Fig. 2. Do. A rhizoidal cell cut off by a cross wall.

Fig. 3. Do. Formation of rhizoids from two adjacent cells.

Fig. 4. Do. Same as Fig. 3, but cross wall formed in one of the two rhizoids.

Fig. 5. *Zygnema* sp. Formation of rhizoids from two adjacent cells of a filament. One of the rhizoids is much elongated and a terminal cell is cut off by a cross wall. The other rhizoid is dichotomously branched.

All × 490.

PLATE IV.

Fig. 1—7. *Mougeotia sp.*, ends of the filaments showing the various stages of coiling. 2 and 4, small fragmented parts of the filament showing coiling.

Fig. 8. *Mougeotia sp.* coiling round itself.

Fig. 9 and 10. *Mougeotia sp.* coiling round *Spirogyra* filaments

Fig. 11—12. *Mougeotia* cells forming lateral haptera.
All × 210.

SOME ATTACHED FORMS OF ZYGNEMACEÆ.

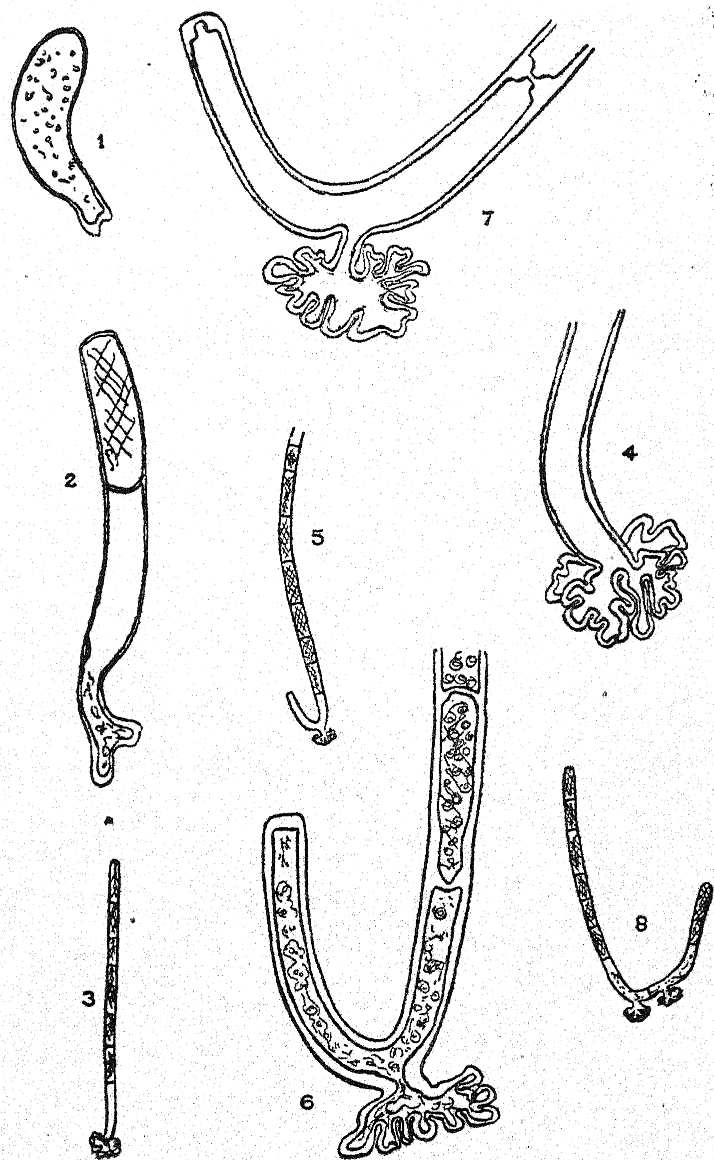


PLATE I.

SOME ATTACHED FORMS OF ZYGNEMACEÆ.

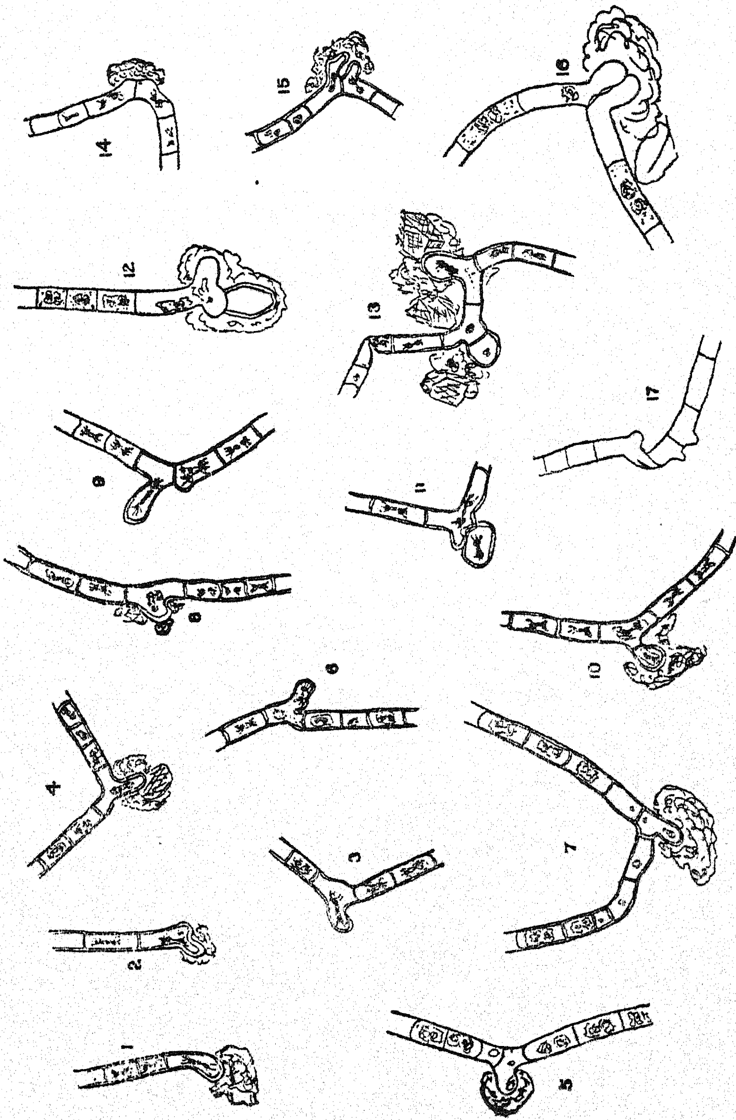


PLATE II.

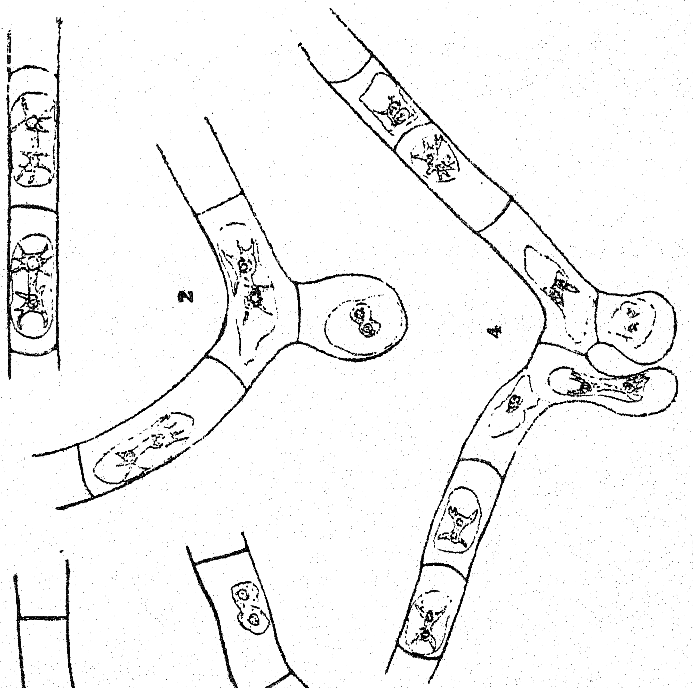


PLATE III.

SOME ATTACHED FORMS OF ZYGNEMACEÆ.

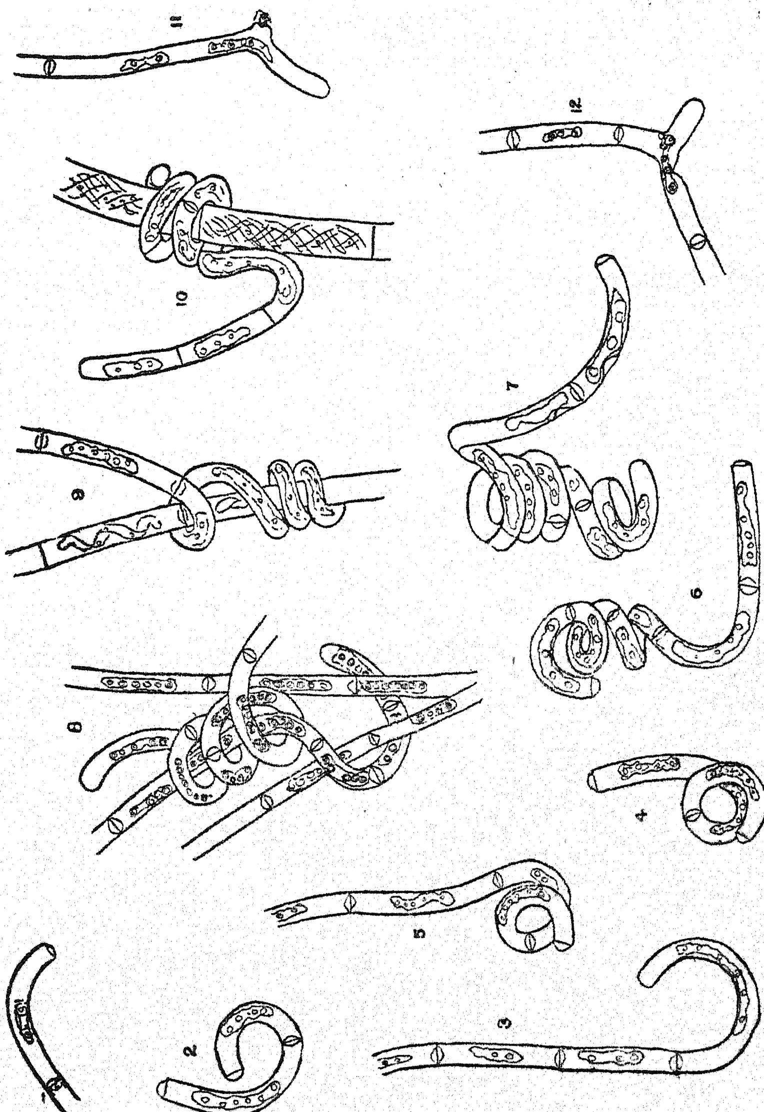


PLATE IV.

A NEW LIVERWORT FROM MADRAS.

BY

S.R. KASHYAP AND M.L. SETHI.

(*Read before the Indian Science Congress in January, 1923*).

The Liverwort described in this paper was one of a collection sent by Prof. Fyson to Prof. Kashyap for identification in 1918. Many of the specimens in this collection were of great interest and at least one was quite new to science. This one forms the subject of this paper and the rest will be described later on. A brief reference to this plant was made by Prof. Kashyap in 1919, in his presidential address to the Botany section of the Indian Science Congress at Bombay.

The plant forms dense patches of intricately overlapping individuals and it is rather difficult to disentangle one complete plant from the whole mass. Since the specimens were preserved in formaline-alcohol, it is not possible to say what was the original colour of the plants, but their general delicate structure indicates that it would probably be yellowish, rather than, deep green.

The plants are translucent, simple or slightly branched dichotomously, and have very long and very narrow lobes. They are strictly dioecious and male plants are even more narrow than the female. Near the apex the lobes are comparatively broad and the notch at the apex is quite distinct but posteriorly they are greatly attenuated. The length of a complete male or female plant is about 12 mm. and the breadth in the male ·3mm. while in the female plant is about. ·4 mm. The thickness of the thallus is about ·2mm., and from 12 to 15 cells. The plants are therefore very thin and slender. The ventral surface bears rhizoids of two kinds as is generally the case in the Marchantiales. The tubercles, however, on the tuberculate rhizoids are very feebly developed. Scales also are present, but they are very small, delicate, hyaline, and distinguishable with difficulty even near the apex, while further back they are either not found at all or occur at long intervals. The cells of the scales contain a few small chloroplasts. The scales are median at the apex but further back they become lateral, as is known to be the case in species of Riccia (Cavers).

On the dorsal surface air-chambers and pores are met with in the anterior part. The air-chambers are small and are arranged in a

single layer. They contain no filaments. As the chambers are directed forwards just behind the apex, they appear in two or more layers in transverse sections, but being quite horizontal further back, they are seen in a single row in such sections. The pores are very few in number, small, quite simple, and restricted to the anterior part. There are no pores in the posterior part of the thallus which forms by far the largest part of the length of the lobe—(six times the length of the anterior part.) Their outline and width are very variable. They may be circular or elongated along the long axis of the thallus. Yet it cannot be said that the air-chambers open by the whole of their width. The number of cells bounding the pores is very variable —8 or more. In the anterior portion the thick central part passes gradually into the wings, but in the posterior region the distinction between the midrib and the wings is not so clear.

Epidermal cells and the cells of the upper region of the thallus are all thin walled and contain chloroplasts. The cells of the thallus as a whole are parenchymatous and thin-walled, but in the posterior egion they are elongated along the long axis of the thallus.

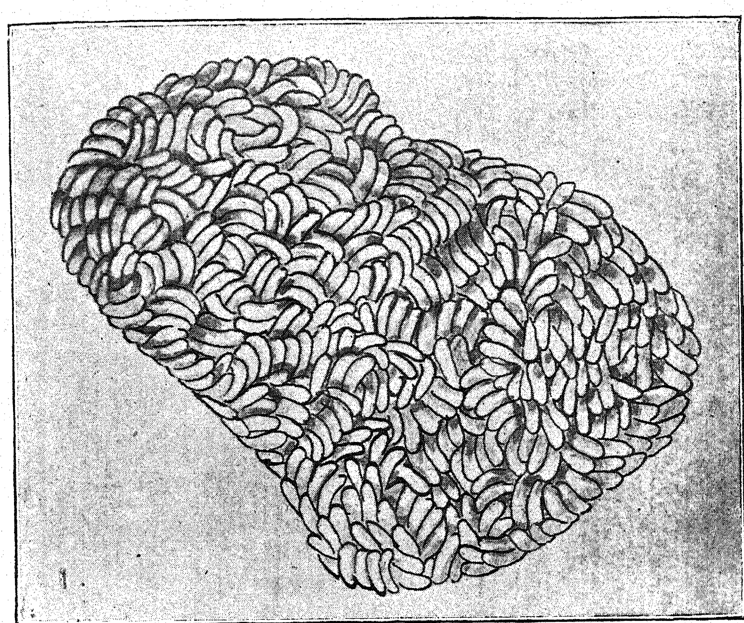
A number of meristematic cells is seen at the apex but no special apical cell could be distinguished. The division of a lobe into two takes place as usual in thallose liverworts by the formation of a middle lobe.

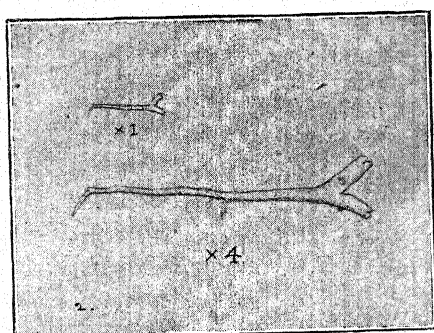
The antheridia are one to four on each male plant. Each is sunk in a pit on the dorsal surface. They are arranged in an acropetal order. They are very inconspicuous, appearing as small black dots from the outside and very difficult to make out. The pore of the pit in which the antheridium lies does not project to the outside. The antheridium is obovate in outline and is very shortly stalked. The tip is more or less pointed as in many of the Marchantiales. The wall of the antheridium consists of hyaline cells. The youngest stage seen showed a few cells in the centre surrounded by a layer of wall-cells.

The female plants bear one to three archegonia (sporogonia later on) in acropetal order in one row. The archegonium is completely enclosed in a pit on the dorsal surface of the thallus and the neck projects outwards very slightly. The sporogonium is very deeply situated and projects very strongly on the ventral surface. Ripe sporogonia are very conspicuous, and appear as black bodies through the thallus projecting from the under surface.

The sporogonium is perhaps the most interesting part of the plant. It has a very small foot consisting of about 5 or 6 large thin-walled cells embedded in the thallus tissue, but no definite seta or even

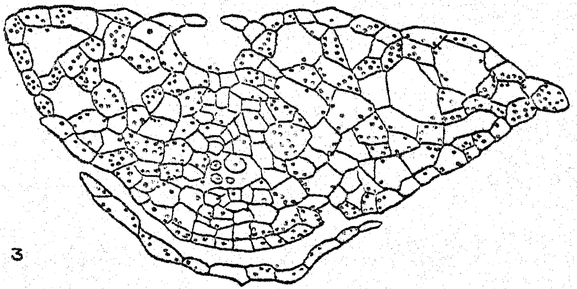
FYSONIA TENERA.





1. A cluster of plants showing habit.
2. Two plants separated out.

Fysonia tenera.



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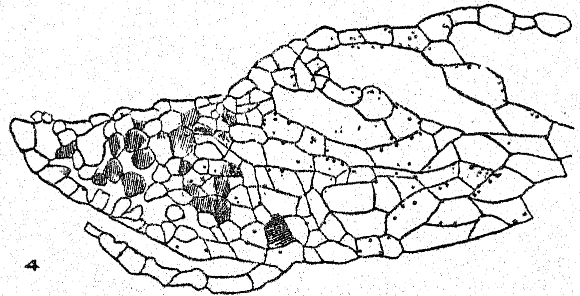

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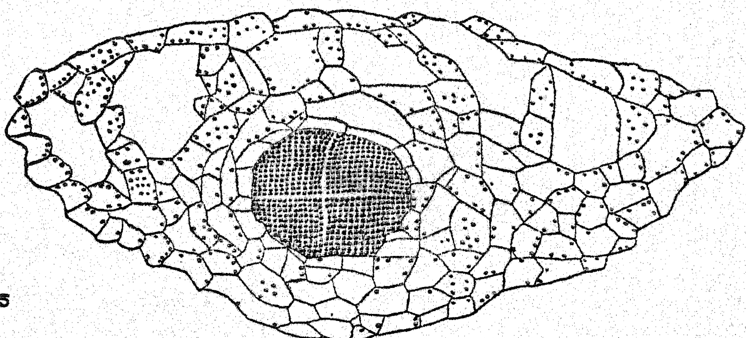
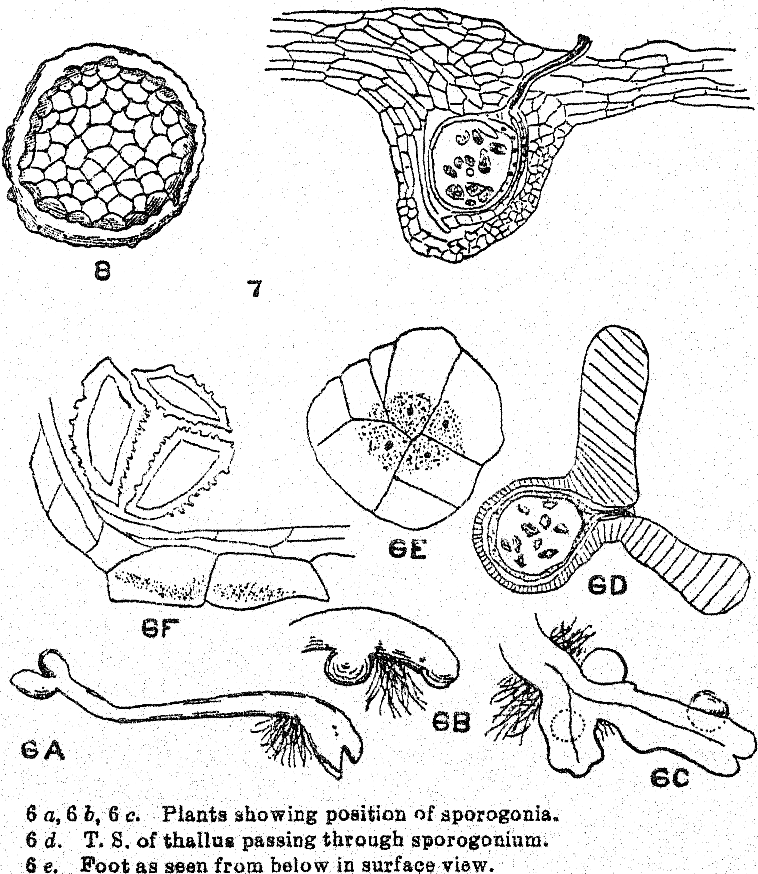


5

3. T. S. of thallus.
4. L. S. thallus.
5. T. S. of thallus passing through an antheridium.

Fysonia tenera.



6 *a*, 6 *b*, 6 *c*. Plants showing position of sporogonia.
6 *d*. T. S. of thallus passing through sporogonium.
6 *e*. Foot as seen from below in surface view.
6 *f*. Foot in L. S. Three spores have also been cut in section.
7. T. S. of thallus showing sporogonium and calyptra.
8. A. single spore.

[illegible]

a constriction below the capsule is present, the foot being joined to the latter by means of a few small cells. The capsule has a wall of one layer of cells which become disorganised at maturity and contains about 120 spores. There is no trace of any sterile cells in the capsule. The spore-mother-cells do not become lobed during division. The spores are opaque and reticulate. There are 7 to 9 reticulations in the diameter. Size 85 to 115 μ.

The plant obviously belongs to the Marchantiales. The presence of two kinds of rhizoids, scales, air-chambers and pores, structure of the sporogonium etc., all point to this conclusion. The general habit is very much like that of a *Riccia* and as a matter of fact it was provisionally referred to that genus before the structure was fully examined. The presence of a foot, however, distinguishes it from that genus. In this respect it resembles the genus *Corsinia* but there are no sterile cells in the capsule. The genus should thus be placed between *Riccia* and *Corsinia*—a very interesting intermediate form which bridges the gap between the *Ricciaceae* and the *Corsiniaceae*. The absence of the airpores in the porterior part of the thallus is also remarkable.

The characters of the genus are given below :—

Fysonia Kashyap n.g.

(after Prof. P.F. Fyson, Prof. of Botany, Presidency college, Madras)

Plants thallose, simple or slightly dichotomous. Lobes long, very narrow, up to 12 mm. long, ·3–·4 mm. broad and ·2 mm. thick. Upper surface flat, lower convex, semicircular in transverse section, Rhizoids smooth and tuberculate, tubercles small. Scales hyaline delicate, very few, not projecting beyond the margins, with chloroplasts. Air-chambers small, empty in one row; pores rudimentary, simple, restricted to a small anterior portion only, each bounded by 8 or more cells, cells thin walled. Epidermis thin walled. Dioecious. Antheridia 1–4 singly in pits; osteoles not projecting. Archegonia 1–3, deeply sunk in pits, necks very slightly projecting; sporogonia 1–3 strongly projecting towards the ventral side; foot of 5 or 6 large cells; seta indistinct; capsule globose; wall of one layer of cells, which becomes disorganised at maturity. Spores opaque, reticulate, 7-9 reticulations in diameter, 85–115 μ. Elaters or sterile cells absent.

Species one, *Fysonia tenera* Kashyap. Characters as above.

THE FLORA OF SIND.

BY

T. S. Sabnis, B.A., M.Sc.

Continued from page 180.

XI. Caryophyllaceae.

1. Spergula *L.*

1. **Spergula arvensis** *L. Sp. pl.* (1753) 440. Loc.: Larkana: " Kirthar Range " (9).

Distrib.: A weed of cultivation in all temperate regions.

2. Polycarpaea *Lamk.*

2. **Polycarpaea corymbosa** *Lam. Tab. Encyc. et Method.* II (1800) 129. Loc.: Karachi: " Jamadar ka Landa " (9).

Distrib.: America, Africa, Trop. Asia, Australia.

2. **Polycarpaea spicata** *Wt. & Arn. in Ann. Nat. Hist. ser.* 1, III (1839) 91. Loc.: Karachi: " Sea-Shore " (9); " Tatta " (9); " Landhi " (9);

Distrib.: Egypt, Abyssinia, Arabia.

XII. Portulacaceae.

1. Portulaca *L.*

1. **Portulaca oleracea** *L. Sp. pl.* (1753) 445.—Verm. N.: Ghol. Loc.: Larkana: Laki, foot of the hill (Sab. B 161, B 171). Sukkur.. Sukkur, fields (Sab. B 531 !). Nawabshah: Pad Idan (Sab. B 562 !): Hyderabad: Kotri, Indus banks (Sab. B 392 !). Thar & Parkar: Mirpurkhas (Sab. B 859 !); Jamesabad, fields (Sab. B 914 !); B 9831 Sanghar (Sab. B 756 !). Fl. and Fr.: October and November.

Uses: Cooked and eaten as a vegetable.

2. **Portulaca quadrifida** *L. Mant.* (1767) 73. Loc.: Karachi: " Karachi " (9).

Distrib.: Africa, Trop. Asia.

3. **Portulaca tuberosa** *Roxb. Hort. Beng.* (1814) 91. Loc.: Karachi: " Jamadar ka Landa " (9); " Malir, river banks " (9).

Distrib.: Ceylon.

XIII. Tamaricaceae.

1 Tamarix *L.*

1. **Tamarix gallica** *L. sp. pl.* (1753) 270. Loc.: Larkana: Larkana coloured soil (Sab. B 99 ;), Sita Road, coloured soil (Sab. B 355 !) Sehwan,—coloured soil (Sab. B 597 !), sand dunes (Sab. B 663 !) Laki, foot of the hill (Sab. B. 81 ; , B 287 !, B 963 !). Sukkar : Sukkar (Sab. B 553 !). Khairpur : Mir's forest (Sab. B 322 !). Hyderabad : Kotri, Indus banks (Sab. B 1203 !). Thar & Parkar : Mirpurkhas, water course (Sab. B 873 !) ; Jamesabad (Sab. B 916 !, B. 1157 !) ; Sanghar (Sab. B. 661 !) ; Umerkot, sand dunes (Sab. B. 739 !). (9 without locality).

Distrib.: Mediterranean region, N. and Trop. Africa, India, S. Asia. Fl. & Fr.: October and November.

Note: Very common on Indus banks and on coloured soil throughout Sind.

2. **Tamarix dioica** *Roxb. Hort. Beng.* (1814) 22. Loc.: Karachi : Karachi (Ticehurst 32268 !), Fl. and Fr.: August.

3. **Tamarix articulata** *Vahl, Symb.* II (1791) 48, t. 32. Loc.: Karachi : Gizri (Sab. B 780 !) ; Magho Pir (Sab. B 211 !), Larkana : Larkana, coloured soil (Sab. B 101 !) ; Sita Road, coloured soil (Sab. B 356 !) ; Sehwan, coloured soil (Sab. B 32 !, B 289 !, B, 290 !, B 607!) Laki, foot of the hill (Sab. B 7 !, B 113 !, B 114 !). Sukkur : Sukkur forest nursery (Sab. B 412 !). Khairpur : Mir's forest (Sab. B 321 !, B 880 !), sandy plains (Sab. B 231 :, B 236 !), Mirwa canal banks (Sab. B 272 !). Nawabshah : Pad Idan (Sab. B 507 !). Hyderabad : Phuleli canal banks (Sab. B 182 !), Kotre, Indus banks (Sab. B 399 !. B 402 !, B 403 !), Thar and Parkar : Mirpurkhas, water course (Sab. B 876 !) ; Sanghar (Sab. B 759 !); Umerkot, sandy plains (Sab. B 1073 !). (9 without locality).

Distrib.: Algeria, S. Africa, Arabia, Baluchistan. Fl. and Fr.; October and November.

Note: Very common, especially on coloured soil, throughout Sind.

4. **Tamarix ericoides** *Rottl. in Gesel. Naturf. Fr. Berl. Neue. Schr.* IV (1803) 214. (9 without locality).

Distrib.: India, Ceylon.

5. **Tamarix stricta** *Boiss. Diag. ser.* 2 (1856) *fasc.* 2, 57. Loc.: (9 without locality).

Distrib.: Baluchistan.

XIV. Elatinaceae

1. Bergia *L.*

1 **Bergia odorata** *Edgew. in Journ. Asiat. Soc. Bèng.* VII (1838) 765. Loc.: Karachi: "Jamadar ka Landa" (9). Larkana: Sehwan, coloured soil (Sab. B 608 !). Hyderabad: Kotri, Indus banks (Sab. B 373 !, B 376 !, B 383 ! B 389 !). Thar and Parkar: Mirpurkhas, water course (Sab. B 845 !, B 952 !); Sanghar (Sab. B 648 !, B 654 !, B 662!).

Distrib.: Trop. Africa, Egypt, Persia, Gujarat. Fl. and Fr.: October and November.

2 **Bergia ammannioides** *Roxb. Hort. Beng.* (1814) 34. Loc.: Karachi: "Karachi" (9). Larkana: Larkana (Sab. B 471 !); "Bubak" (9); Sehwan, coloured soil (Sab. B 172 !, B 267 !).

Distrib.: Konkan, Deccan, Senegambia, Nubia, Abyssinia, Australia. Fl. and Fr.: October.

XV. Malvaceae.

1. Althaea *L.*

1. **Althaea Ludwigii** *L. Mantiss.* (1767) 98. Loc.: Larkana "Sehwan" (9). Hyderabad: Kotri, Indus banks (Sab. B 380 !); "Hyderabad" (9). "Shikarpur and Sukkur" (9). (9 without locality).

Distrib.: Mediterranean region, S. Africa and W. Asia. Fl. and Fr.: November.

2. Malva *L.*

1 **Malva rotundifolia** *L.* Sp. pl. (1753) 688. (9 without locality).

Distrib.: Europe, N Africa, N. and W. Asia.

2 **Malva parviflora** *L. Amoen. Acad. ed.* 2, III (1787) 416. Loc.: Karachi, "Karachi" (9), "Gurapad" (9).

3. Sida *L.*

1 **Sida veronicifolia** *Lam. Encyc.* I (1783) 5. (9 without locality).

Distrib.: Trop. and subtrop. regions of the globe.

2 **Sida spinosa** *L. Sp. pl.* (1753) 683. Loc.: Karachi: Magho Pir hill (Sab. B 204 !). Khairpur: Mir's forest (Sab. B 338 !). Hyderabad Phuleli canal banks (Sab. B 141 !, B 158 !). Thar and Parkar: Sanghar (Sab. B 760 !); Umerkot, garden (Sab. B 858 !). (9 without locality).

Distrib.: Trop. and subtrop. regions of both hemispheres. Fl. and Fr.: October and November.

3 **Sida grewioides** *Guill. Perr. et A. Rich. Fl. Senegamb.* I (1830) 71. Loc.: Karachi "Karachi" (9). Hyderabad: Hyderabad, rocky plateau (Sab. B 243 !). (9 without locality, common).

Distrib.: Punjab, Baluchistan, extending to Arabia and Trop. Africa. Fl. and Fr.: October and November.

(*To be continued.*)

NOTICE

The following has been received by Dr. Dudgeon :—

31, TENNISON AVENUE,
CAMBRIDGE,
ENGLAND.

DEAR SIR,

At a representative meeting of British Botanists held in March 2nd, it was decided to hold an Imperial Botanical Conference during July, 1924 on the occasion of the Empire Exhibition. Your co-operation in this matter is earnestly requested.

We are desired therefore by the Executive Committee to enquire if you would be able to attend this Conference, and to invite your views as to its scope as it is particularly desired that topics of special interest to overseas botanists should be discussed thereat. The favour of an early reply to the Secretary on the enclosed form is requested.

We shall be glad also if you will kindly bring this letter to the notice of any of your colleagues who may not receive a copy.

Yours faithfully,

DAVID PRAIN,
Chairman.

F. T. BROOKS,
Secretary.

(ENCLOSED FORM)

Imperial Botanical Conference

Address :—

(1) Are you likely to be able to attend the Imperial Botanical Conference to be held in July 1924 ?

(2) Have you any suggestions as to topics which might be discussed at the Conference ?

Signed...

CURRENT LITERATURE.

TAXONOMY

Isoetaceae

Pfeiffer, Norma E. Monograph of the Isoetaceæ. *Annals of the Missouri Botanical Garden, Vol. 9. No. 2, April 22, 1923.*

Some 54 species of Isoetes are described, and classified in four sections distinguished by the megaspores having tubercules, spines, irregular crests, or irregular reticulations, on one or more of the faces. The separation of the species proved rather difficult in some cases, but these characters seem the least affected by the environment and so are most valuable in classification.

Though the first two species to be described by Linnæus, were an European and an Indian (apparently the only Indian species) the genus belongs chiefly to North America. Europe has a dozen species and Oceania eight. The Indian I. coromandeliana is reported apparently only from near Madras, but those who know South India will expect it to be widely distributed over the peninsula if not in Northern India. More collecting of water plants it is clear is called for on the part of Indian Botanists.

P.F.F.

Physiology

Jivanna Rao, P. S. An enquiry into the cause of Bud and Boll shedding in Cotton. *Year Book of the Madras Agricultural Department, 1922.*

Premature shedding of buds and bolls leads to an enormous amount of waste in all cottons, and has been investigated by many workers. The writer of this paper emphasises the importance of a correct agreement in the osmotic pressures of the pollen grains and the tissue of the stigma, and he considers a weakening of one or other, brought about by continual self-pollination is the cause of failure to set seed, while the shedding of the buds is also due to a weakening of the osmotic pressure of the cell sap at a critical time in the plants life history.

P.F.F.

Jivanna Rao, P. S. A note on the Pollen Sterility and the Shedding of Bud and Fruit in Thespesia populnea. *Year Book of the Madras Agricultural Department, 1922.*

Thespesia populneas is frequently almost or quite sterile, shedding buds and immature bells in large quantities. But two plants raised from seed are now bearing perfectly fertile flowers. The author suggests, though he has

not yet the data for proving this, that failure to set seed is connected with vegetative propagation, which is very easy in this species. Flowers of the sterile type of tree are larger than those of the fertile, and the writer considers a quasi-mechanical cause, the inability of the pollen grains to penetrate the extra long styles, produced on the vegetatively propagated plants, together with a dilution of the osmotic strength of both pollen grain and pistil, is the explanation.

P.F.F.

Origin of Angiosperms

The following is taken from the minutes of a meeting of the Linnean Society of London, on March 15, 1923.

Mr. JOHN PARKIN brought forward a paper on "The Strobilus Theory of Angiospermous Descent," of which the following is an abstract :—

The author did not abandon or seriously modify the theory of the origin of Angiosperms (Flowering Plants) brought before the Society in 1907 by the late Dr. Newell Arber and himself.

The idea that the flower has evolved by reduction from a bisexual cone of a special type is further elaborated. This *Anthostrobilus* is characterized by having the microsporophylls borne on the axis invariably below the megasporophylls; it is peculiar to the Angiosperms, Bennettitales and Gnetales. Other known bisexual cones, as those of *Calamostachys*, *Lepidostrobus*, *Selaginella*, bear the two kinds of sporophylls in the reverse order on the axis, supporting the view that the anthostrobilate groups have had a common descent. From the Pteridosperms, strobilate plants arose either (1) by the segregation of the two kinds of sporophylls into unisexual cones, or (2) by their aggregation into one and the same cone. The anthostrobilus may have been called into being through the substitution of insect-pollination for wind-pollination.

The Angiosperms are regarded as a monophyletic group; the primitive feature of the Amentiferæ are treated of in detail; this assemblage does not possess a monopoly of these, and the families composing it may through extreme floral reduction have come from polypetalous forms. The Monocotyledons are regarded as of monophyletic origin from the Dicotyledons and of Ranalian extraction.

The 8-nucleate sac is taken as primitive for Angiosperms and any departures therefrom as derived. The anatropous form of ovule is now suggested as primitive for Angiosperms and the orthotropous as derived.

Engler's system is subjected to strong criticism, and adherence to it considered now to have a retarding influence on the progress of systematic botany. A return to the Ranales as the starting-point for the evolutionary study of the flower is advocated, and a new authoritative classification based on this alliance is held to be very desirable.

Dr. D. H. SCOTT opened the discussion by dwelling upon the recent discoveries by Dr. G. R. WIELAND, and showed lantern-slides exhibiting Bennettitales from them.

Mr. H. HAMSHAW THOMAS (visitor) contended that all evolutionary theories must be concordant with Palæobotanical facts. Recent work shows that in the Middle Jurassic a group of plants existed as Angiosperms, though considerably different from those now existing. In some of the Jurassic Bennettitales are a few characters similar to those occuring in Angiosperms of to-day, but differing markedly in the structure of the gynæcium.

In the same bed as *Williamsoniella*, the speaker had unearthed female inflorescences and fruits of two genera which are undoubtedly Angiosperms, though their microsporangia or male flowers have not been found. These genera are *Gristhorpia* and *Caytonia* and were displayed in a series of lantern-slides: they probably bore leaves of the type long known as *Sagenopteris* formerly ranked amongst the Marsileaceæ on account of their shape and reticulate venation.

It is quite open to question whether these Caytoniales had any relationship to modern Angiosperms. They show that the Angiospermous type of gynæcium evolved at an early date, and that the plants which achieved this advance still had characters of a Gymnospermous type, especially as regards their seeds.

Professor F. W. OLIVER inquired what was the author's view as to the closing of the carpels from the open state.

Dr. A. B. RENDLE contended that the paper consisted of two subjects which were unconnected with each other: the origin of Angiosperms and Bennettitales. He deprecated the designation of the theory as the Strobilus theory; that title would be equally applicable to other theories. He also protested against the attempt to derive the whole of the modern Angiosperms from the Ranalian plexus. The modern German system had done good service in indicating the affinities of certain orders of Dicotyledons, which had been separated from their allies by the French system, developed by Bentham and Hooker, on account of their apetalous character. But there were groups, such as the Amentiferæ, which might be regarded as descendants of older forms, contemporary with, or earlier than the immediate ancestors of the Ranales. There were presumably many stages in the evolution of the modern Angiosperms, and it seemed more in accordance with facts to regard some of the modern apetalous groups as descendants from one or other of these.

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(Formerly "The Journal of Indian Botany".)

VOL. III. JUNE, 1923. No. 8.

THE VEGETATION OF LALITPUR—AN ECOLOGICAL SKETCH.

BY

MABEL HARTOG, B.SC.

The Subdivision of Lalitpur is almost in the centre of India, only a degree or so north of the Tropic of Cancer. It lies on the northern slope of the Central Indian Plateau, and forms part of the wild and rocky tract of country which stretches from the forests of the Vindhyan Hills down towards the fertile fields and populous cities of the Gangetic Plain. From an ecological point of view the district has considerable interest as differences of soil and variety of physical features have given rise to a number of distinct formations.

Ecological Factors.

Across the south of the district run the northernmost flat topped spurs of the Vindhyan Hills, which reach a height of 2000 ft. Broadly speaking, the remainder of the district is an undulating plain about 1000 ft. above sea level. The underlying rock is almost entirely red gneiss, but it is overlaid along the foot of the Vindhyan Hills by a layer of black cotton soil. This thins out and gradually disappears to the north: here the gneiss is only covered by a shallow layer of red soil, and crops out at the surface in innumerable jagged hills, piles of boulders, and slabs of rock.

Between the black cotton soil of the south and the red soil area of the north is a transition zone composed of a mixture of the two, and this also bears its own distinct vegetation. The whole subdivision is a hot dry country, almost rainless for 8 months of the year. Much of the annual rainfall, which averages only 40 inches, runs off at once into the numerous water courses. The rivers flow in deep rocky beds and even in the rains do not overflow their banks sufficiently to have an appreciably fertilising effect on the soil through which they pass.

General Aspect of the Vegetation.

Without being of a desert type the vegetation is distinctly xerophytic in character. Nearly all the trees and shrubs are deciduous. There are no herbaceous epiphytes and very few cryptogams. The hills are covered with dry forest, and the more level parts of the area, where not under cultivation, are covered with *scrub*, which varies in type according to the soil.

The prevalent xerophilous characters, found in different degrees in the various formations, are :—

(1) development of thorns, (especially in the scrub species) as in Zizyphus, Carissa, Celastrus, Acacia spp. Mimosa, Flacourtia, Balanites, Capparis, Gardenia, Randia, Aegle, Erythrina, Bridelia, etc.

(2) thickening of the leaves as in Butea, Lagerstroemia, Diospyros Bassia, Buchanania, Tectona, Carissa, Celastrus, Gardenia, Cassia fistula, etc.

(3) reduction in the number of leaves and branches as in the case of species such as Bassia, Odina, Boswellia, Garuga, Sterculia, Buchanania, Cochlospermum, Terminalia belerica, etc., which form the tallest and finest trees. In these trees nearly all the shoots in any year are produced from terminal buds and not from axillary buds of last year's leaves, so that the total number of leaves and branches on the tree increases only very slowly from year to year. At the same time all the leaves are kept in connection with a strong current of sap.

(4) fall of the leaf during the driest months of the year and consequent reduction of transpiration. The time of leaf-fall varies with the species and also with the situation of the individual. Trees in moister situations may retain their foliage two months or so after those of the same species in less favourable positions have shed their leaves.

(5) mobility of the leaves, enabling them to assume a vertical position during the hours of strongest sunlight as in Bridelia, Casearia, Phyllanthus, Cassia fistula, and the young leaves of Diospyros, Butea and many other species.

(6) protection of the chlorophyll of the young leaves by red coloration and development of tomentum as in Butea, Flacourtia, Diospyros, Bassia, etc.

(7) great development of the underground system of trees and shrubs.

The Formations.

There are 6 distinct Formations, *viz.*

(1) Formation of Rocky Red Soil.

(2) Formation of Black Cotton Soil.

(3) Formation of Soil composed of a mixture of the Red soil and the Black Cotton soil.

(4) Formation of Sandstone Hills.

(5) Formation of Damp Ground bordering rivers, nullahs and tanks.

(6) Aquatic Formation.

The red soil of the north is a coarse sand, poor in humus and very shallow. It retains very little moisture near the surface, but on the hills and even among the groups of boulders in the scrub, it is able to support woody vegetation because here the subsoil is more broken up and the deep roots of the trees penetrate down between the rocks, and obtain sufficient moisture to reach a certain stage of development. On all the gneiss hills we find a poor type of dry forest. By the stature of the trees one can gauge the amount of water available in the soil. Nowhere do they reach a greater height than 20 or 25 feet or a diameter of more than about 9 inches. In situations where there is least soil they become mere stunted shrubs. A few species such as Anogeissus pendula and Mitragyna parvifolia in such situations assume a gnarled and dwarf habit of growth very similar to that of Cotoneaster, and are almost unrecognizable from their descriptions in the floras. I came to the conclusion that this curious growth form was chiefly due to the fact that the young shoots of these trees, being almost the only unarmed species with relatively thin leaves, are devoured by animals so persistently as to alter the whole habit of the plant.

As a consequence of the low water content of the surface layers of the red soil, the ground vegetation is very poor. There is very little undergrowth on the hills, just an open association of short grass and low herbs.

Coming now to the red soil scrub-land we find that it bears a vegetation of low scattered shrubs of which the dominant species are Butea frondosa, Lagerstroemia parviflora and Zizyphus nummularia. These do not reach a height of more than a few feet; but the land has been so much interfered with by cultivation that it is difficult to say how far this is due to natural causes.

The ground layer is again just an open association consisting of scattered herbs of a number of different species of which many are prostrate in habit. It forms no continuous carpet of vegetation even in the rains.

Let us now contrast with this the vegetation of the black cotton soil. As is well known, black cotton soil is a very fine clay highly retentive of moisture. It becomes almost liquid in the rains and on drying a peculiar shrinkage takes place resulting in the formation of great holes and innumerable cracks. The vegetation is as characteristic in appearance as the soil. Owing to the high water content of

the surface layers we have a closed ground association dominated by tall grasses. For the same reason the black cotton soil is agriculturally by far the best soil in the area. Saccharum spontaneum is the dominant grass and in places covers the ground almost to the exclusion of other species; it is a source of great anxiety to the cultivator. Anthistiria scandens is also very abundant.

On the other hand the black cotton soil bears the poorest of woody vegetation and is evidently unsuitable for deep-rooted plants possibly owing to its constant shrinkings and shiftings which extend far below the surface. The dominant, almost the only woody species, are solitary stunted shrubs of Acacia leucophlea and Butea frondosa and these are generally found only at intervals of 25 or 30 feet.

Turning now to the formation of the *mixed* soil which is typically brown in colour without holes or cracks, we find that the characteristic vegetation is a *thick* scrub consisting of masses of thorny shrubs from 6 to 8 feet in height. These shrubs tend to grow in groups which form tangled thickets with a comparatively rich fringe of tall grasses, herbs and climbers round them, and a sparser ground covering of grasses and herbs between. There is sufficient water available in the soil to support a far larger number of shrubby plants on a given area than in the red soil scrub. The dominant shrub is Carissa spinarum which is evergreen and gives the whole formation a very green appearance. Other subdominant species are Celastrus senegalensis, Acacia catechu and Zizyphus nummularia.

Having compared the types of scrub found on the different soils of the area, let us now contrast the forest of the Vindhyan Hills in the south with the forest of the gneiss hills in the north. The soil on the Vindhyans is very much finer in texture and more retentive of moisture than the red soil from the gneiss; and in most parts it is also very much deeper.

As a result of these qualities it is characterised by

(1) greater variety of species.

(2) more flourishing growth with fewer xerophilous characters.

(3) an abundance of grasses, forming in all the cuttings and open spaces a typical closed grass-land association.

(4) relative luxuriance of undergrowth climbers.

The forest consists of about 80 mixed species, some abundant and some uncommon but more or less evenly distributed. The trees may reach a height of 80 feet though the average is not more than half that amount.

Species of Andropogon are among the most abundant of the grass-land association which averages a height of 2 or 3 feet.

We come now to the Formation of Damp Ground and the Aquatic Formation. The rivers are generally outlined by quite characteristic trees such as Terminalia glabra, Ficus glomerata, Eugenia Jambolana, etc. These trees are unarmed and have a relatively dense foliage corresponding to the larger amount of water available in the soil.

On the banks of the rivers and round the tanks is an association of thin leaved damp-loving herbs including many annuals which spread as fast as the ground is uncovered after the rains. They are joined by invaders from the scrub and cultivated land. In places there is a closed association with Marsilea as the dominant species.

The Aquatic Formation consists of typical hydrophytes and the majority of the genera are of very wide geographical distribution. Round the tanks one may distinguish.

(1) submerged leaf association.
(2) floating leaf association.
(3) reed swamp association.

The reed swamp association sometimes forms a dense closed association, and is often entirely absent, probably because it can only flourish where the soil is marshy throughout the year.

In the river beds there is also an association of submerged species besides those interesting plants such as Crinum defixum and Rhabdia lycioides which grow in the rocky beds, and are submerged for part of the year, but I was not able to study these in any detail.

The above is but the barest sketch of the vegetation of the area. For want of space many features have not been touched upon while there are many problems which need fuller investigation.

Appendix to paper on Vegetation of Lalitpur —An Ecological Sketch.

Below are appended lists of the most characteristic species of the different formations as far as they have been identified.

The nomenclature is taken from J. F. Duthie's "Flora of the Upper Gangetic Plain."

1. Formation of Rocky Red Soil.

(1) Woodland Association.

Tree and Shrub Layer.

Abundant.

Lagerstroemia parviflora
Diospyros tomentosa
Zizyphus Xylopyra
Dendrocalamus strictus
Mitragyna parvifolia
Anogeissus pendula
Holoptelea integrifolia

Abundant—(*Contd.*)

Flacourtia Ramontchi
Butea frondosa
Zizyphus Oenoplia

Frequent.

Tectona grandis
Gardenia turgida

FREQUENT—(*Contd.*)

Bauhinia racemosa
Acacia Catechu
Boswellia serrata
Ficus tomentosa
Odina Wodier
Nyctanthes Arbor-tristis
Holarrhena antidysenterica

UNCOMMON.

Aegle Marmelos
Schrebera Swietenioides
Sterculia urens
Anogeissus latifolia
Albizzia Odoratissima
Erythrina suberosa
Flueggea microcarpa
Dalbergia paniculata
Acacia leucophlea
Phyllanthus Emblica
Elæodendron Glaucum

UNCOMMON—(*Contd.*)

Helicteres isora
Alangium Lamarckii
Saccopetalum tomentosum
Grewia tiliæfolia
Glochidion sp.
Cordia Rothii
Euphorbia neriifolia
Acacia pennata
Mimosa rubicaulis

RARE.

Schleichera trijuga
Tamarindus indica (naturalised)
Cochlospermum Gossypium
Grewia scabrophylla
Pterocarpus marsupium
Dalbergia lanceolaria
Bridelia retusa
Cassia fistula
Albizzia procera

Climbers.

Gymnema Sylvestre
Acacia pennata
Capparis Sepiaria
Capparis horrida
Vitis latifolia
Vitis trifolia
Dioscorea sp.
Cardiospermum Halicacabum
Momordica dioica
Abrus Precatorius
Ichnocarpus frutescens
Cryptolepis Buchanani
Galactia villosa
Celastrus paniculata
Ipomæa sinuata
Cissampelos Pareira
Cocculus villosus
Trichosanthes palmata
Marsdenia volubilis

Ground Layer.

ABUNDANT.

Barleria prionitis
Cassia obtusifolia
Cassia pumila
Justicia simplex
Tubiflora acaulis
Tridax procumbens
Indigofera cordifolia
Spermacoce stricta
Sida veronicaefolia
Glossocardia linearifolia
Tephrosia villosa
Ionidium heterophyllum
Evolvulus alsinoides
Cyanotis sp.
Ruellia prostrata

ABUNDANT—(*Contd.*)

Euphorbia hirta
Alysicarpus bupleurifolius
Phyllanthus sp.
About 12. Gramineæ spp.
3. Cyperaceæ spp.
2. Ferns
1. Lycopodium
1. Moss
Triumfetta neglecta
Spermacoce hispida
Sida cordifolia
Hibiscus micranthus
Celosia argentea
Bidens pilosa
Pupalia lappacea

Ground Layer—(Contd.)

ABUNDANT—(*Contd.*)

Crotalaria hirta
Achyranthes aspera
Curculigo orchioides
Cleome viscosa
Vernonia cinèrea
Convolvulus pluricaulis
Mollugo pentaphylla
Andrographis echioides
Euphorbia spp.

ABUNDANT—(*Contd.*)

Cassia Absus
Anisochilus carnosus
Polycarpea corymbosa
Melhania futteyporensis
Lepidagathis trinervis
Sesamum indicum
Chenopodium album
Boerhaavia diffusa

(2) Red Soil Scrub Association.

Shrub Layer.

DOMINANT.

Butea frondosa
Lagerstroemia parviflora
Zizyphus nummularia

ABUNDANT.

Flacourtia Ramontchi
Acacia Catechu
Diospyros tomentosa
Zizyphus Oenoplia

OCCASIONAL.

Anona squamosa (naturalized)
Gardenia turgida
Dendrocalamus strictus
Carissa spinarum
Acacia leueophlea
Zizyphus Xylopyra
Mitragyna parvifolia
Celastrus Senegalensis

Climbers.

Galactia villosa
Convolvulaceæ sp.
Cissampelos Pareira

Ground Layer.

Evolvulus alsinoides
Tridax procumbens
Cassia obtusifolia
Spermacoce stricta
„ hispida
Echinops echinatus
Sida veronicaefolia
Vernonia cinerea
Argemone mexicana
Tephrosia purpurea
„ pumila
Indigofera enneaphylla
Lepidagathis Hamiltonii
Tubiflora acaulis
Ionidium heterophyllum
Blepharis molluginifolia
Justicia simplex
Chenopodium album
Triumfetta neglecta
„ rhomboidea
Cassia pumila

Euphorbia hirta
Bidens pilosa
Glossocardia linearifolia
Achyranthes aspera
Cyanotis sp.
Indigofera cordifolia
„ articulata
Alysicarpus monilifer
Boerhaavia diffusa
Phyllanthus sp.
Launea nudicaulis
Trichodesma sp.
Solanum xanthocarpum
Heylandia latebrosa
Blumea erianthia
„ Oxyodonta
Oldenlandia Corymbosa
Heliotropium strigosum
Corchorus trilocularis
Lepidagathis trinervis
Biophytum Sensitivum

Ground Layer—(Contd.)

Eclipta erecta
Ocimum sp.
Desmodium trifolium (in shade of Bassia)
Waltheria indica
Merremia hastata
Gloriosa superba
Convolvulus sp.
Pupalia lappacea.
Gramineae spp.
Cyperaceae spp.

2. Formation of Black Cotton Soil.

Shrub Layer.

Dominant.

Butea frondosa
Acacia leucophlea

Occasional.

Acacia arabica
Carissa spinarum
Zizyphus nummularia

Uncommon.

Diospyros tomentosa
Acacia Catechu
Celastrus Senegalensis
Zizyphus Oenoplia

Climbers.

Abundant.

Vitis trifolia
Cissampelos Pareira
Rhynchosia minima
Momordica dioica

Occasional.

Atylosia Scarabaeoides
Marsdenia volubilis
Cocculus villosus
Rivea hypocrateriformis

Ground Layer.

Dominant.

Saccharum spontaneum
Anthistiria scandens

Frequent.

About 10 other Gramineae spp.
Enicostema littorale
Triumfetta rhomboidea
Corchorus fascicularis
Indigofera linifolia
Hemigraphis dura
Evolvulus alsinoides
Trichodesma indicum
Alysicarpus bupleurifolius
Biophytum sensitivum
Euphorbia spp.
Spermacoce stricta
Orthosiphon pallidus
Polygala erioptera
Tridax procumbens

Frequent—*(Contd.)*

Neptunia triquetra
Merremia hastata
Melothria maderaspatana

Occasional.

Hibiscus trionum
Cyperaceae sp.
Curculigo orchioides
Cassia obtusifolia
Calotropis procera
Caesalpinia linifolia
Justicia simplex
Heylandia latebrosa
Erigeron asteroides
Cleome simplicifolia
Hibiscus cancellatus
Chrysanthellum indicum
Sida spinulosa
Cyperaceae sp.

3. Formation of Mixed Soil.

Shrub Layer.

Dominant.

Carissa spinarum

Very Abundant.

Zizyphus nummularia
Celastrus Senegalensis
Acacia Catechu

Abundant.

Balanites aegyptiaca
Zizyphus Oenoplia
Mimosa rubicaulis

Frequent.

Diospyros tomentosa
Butea frondosa
Acacia leucophlea
Woodfordia floribunda
Acacia arabica
Phoenix acaulis
Flueggea Microcarpa

Occasional.

Gardenia turgida
Flacourtia Ramontchi
Bombax malabaricum

Climbers.

Abundant.

Gymnema sylvestre
Rhyncosia minima
Cissampelos Pareira
Ichnocarpus frutescens
Cocculus villosus
Atylosia scarabaeoides
Abrus precatorius
Vitis trifolia
„ indica
„ latifolia
Dioscorea sp.
Cryptolepis Buchanani
Cuscuta reflexa (parasite)

Occasional.

Rivea hypocrateriformis
Cardiospermum Halicacabum
Momordica dioica
Capparis horrida
„ sepiaria
Cucumis trigonus
Leea aspera
Pergularia pallida
Marsdenia tenacissima

Ground Layer.

Andropogon contortus,
Anthistiria scandens
Enicostema littorale
Heylandia latebrosa
Cassia obtusifolia
„ pumila
Neptunia triquetra
Indigofera linifolia
„ cordifolia
„ trita
Spermacoce stricta
Erigeron asteroides
Evolvulus alsinoides
Justicia adhatoda
Grewia hirsuta
Sida spinulosa
Tubiflora acaulis
Chrysanthellum indicum

Phyllanthus sp.
Euphorbia sp.
Trichodesma sp.
Arisaema sp.
Gloriosa superba
Orthosiphon pallidus
Ocimum sp.
Barleria prionitis
Launæa nudicaulis
Hemigraphis dura
Inula indica
Triumfetta rhomboidea
Crotalaria sericea
Spermacoce hispida
Clerodendron serratum
Tridax procumbens
Polygala chinensis
„ erioptera

Ground Layer—(Contd.)

Corchorus trilocularis
Rungia repens
Eclipta erecta
Lepidagathis Hamiltonii
Ionidium heterophyllum
Ruellia prostrata
Commelina sp.
Glossocardia linearifolia
Biophytum sensitivum
Vernonia cinerea
Cyperaceæ spp.

4. Formation of Sandstone Hills

Tree and Shrub Layer.

ABUNDANT.

Lagerstroemia parviflora
Diospyros tomentosa
Zizyphus Oenoplia
Boswellia serrata
Odina Wodier
Helicteres Isora
Mimosa rubicaulis
Mitragyna parvifolia
Adina cordifolia
Anogeissus latifolia
„ pendula
Cochlospermum Gossypium
Sterculia urens
Grewia laevigata
Acacia Catechu.
Gardenia turgida
Gardenia latifolia
Aegle Marmelos
Nyctanthes Arbor-tristis
Thespesia macrophylla
Holarrhena antidysenterica
Casearia tomentosa
Wrightia tinctoria
Alangium Lamarckii
Tectona grandis
Terminalia tomentosa
„ belerica
Dendrocalamus strictus
Buchanania latifolia
Ficus tomentosa
Vitex negundo

FREQUENT.

Euphorbia neriifolia
Schleichera trijuga
Hymenodictyon excelsum
Erythrina suberosa
Garuga pinnata
Albizzia odoratissima
Acacia leucophlea

FREQUENT—(*Contd.*)

Flueggea microcarpa
Zizyphus xylopyra
Phyllanthus emblica
Bauhinia racemosa
Randia dumetorum
Cassia fistula
Flacourtia Ramontchi
Bombax malabaricum
Bassia latifolia
Ficus religiosa
Ficus bengalensis
Premna mucronata
„ barbata
Grewia hirsuta
„ tiliæfolia
Butea frondosa
Kydia calycina
Schrebera swietenioides
Albizzia procera
Tamarindus indica
Saccopetalum tomentosum
Bridelia retusa
Ougeinia dalbergioides
Celastrus Senegalensis
Elæodendron glaucum

UNCOMMON.

Eriolæna hookeriana
Dalbergia lanceolaria
Dolichandrone falcata
Cratæva religiosa
Careya arborea
Randia uliginosa
Ficus sp.
Bauhinia tomentosa
Dalbergia latifolia
Pterocarpus marsupium
Albizzia Lebbek
„ procera
Millettia auriculata

Climbers.

Vitis trifolia
,, indicum
,, latifolia
Marsdenia tenacissima
Gymnema sylvestre
Ichnocarpus frutescens
Cissampelos Pareira
Cucurbitaceæ spp.
Convolvulaceæ spp.
Dioscorea spp.
Jasminum pubescens
Ipomoea sepiaria
Leea aspera
Momordica dioica
Galactia villosa
Trichosanthes cucumerina
Cryptolepis Buchanani
Cucumis trigonus
Acacia pennata
Cardiospermum Halicacabum
Atylosia scarabaeoides
Hemidesmus indicum
Capparis sepiaria
Abrus precatorius
Capparis horrida
Mucuna pruriens
Asparagus racemosa
Celastrus paniculata
Combretum decandrum
Smilax sp.
Holostemma Rheedianum

Ground Layer.

Tubiflora acaulis
Ruellia prostrata
Euphorbia hirta
Cassia pumila
Cassia obtusifolia
Orthosiphon pallidus
Enicostema littorale
Spermacoce hispida
Tridax procumbens
Evolvulus alsinoides
Barleria Prionitis
Phyllanthus cristata
Sida cordifolia
Ipomoea pestigridis
Curculigo orchioides
Cyanotis, sp.
Hedychium, sp.
Gloriosa superba
Arisaema, sp.
Cleome viscosa
Hibiscus. sp.
Aeschynomene indica
Commelina, sp.
Clerodendron serratum
Impatiens, sp.
Indigofera enneaphylla
Vernonia cinerea
Sclerocarpus africanum
Ocimum basilicum
Tribulus terrestris
Ionidium heterophyllum
Hibiscus Solandra
Polygala chinensis
Leucas cephalotis
Justicia simplex
Glossocardia linearifolia
Costus speciosus
Sesamum indicum
Heliotropium zeylanicum
,, marifolium
Lochnera pusilla
Clitoria sp.
Melothria heterophylla
Ruellia suffruticosa
Indigofera oblongifolia
Desmodium latifolium
Waltheria indica
Daedalacanthus purpurascens
Orchidaceae sp.
Pueraria tuberosa
Celosia argentea
Plumbago zeylanica
Abutilon indicum
Blepharis molluginifolia
Linaria ramosissima
Leucas mollissima
Biophytum sensitivum
Loranthus longiflorus } parasites
Viscum, sp. }
About 15 Gramineae, spp.
Cyperaceae, spp.
3 Fern spp.
1 Liverwort
1 or 2 Moss, spp.
A few Fungi

5. Formation of Damp Ground.

Species of Rivers and Nullahs with steep banks.

Terminalia glabra
Ficus glomerata
Combretum decandrum
Eugenia Jambolana
Ehretia laevis
Woodfordia floribunda
Mimosa rubicaulis
Mallotus philippinensis
Pongamia glabra
Ficus hispida
Phoenix humilis (often found on sides of small nullahs)

Herbs of Damp Ground.

Limnophila racemosa
„ gratioloides
Ludwigia parviflora
Dentella repens
Coldenia procumbens
Gnaphalium indicum
Caesulia axillaris
Bergia ammanioides
Polygonum spp.
Sphaeranthus indicus
Jussieua suffruticosa
Cyathocline lyrata
Hoppea dichotoma
Ammania tenuis
Ammania baccifera
Canscora diffusa
Sutera glandulosa
Ilysanthes parviflora
Veronica anagallis
Asteracantha longifolia
Lippia nodiflora
Moniera cuneifolia
Glossostigma spathulatum
Hygrophila polysperma
„ serpyllum
Sagittaria sp.
Various Gramineæ spp.
„ Cyperaceae spp.
Marsilea sp.
Equisetum sp.

6. Aquatic Formation.

(1) Submerged leaf association.

Ceratophyllum demersum
Vallisneria sp.
Utricularia flexuosa
Lagarosiphon Roxburghii
Blyxa sp.
Potamogeton crispus
Other Naiadaceae spp.
Hydrilla verticillata

(2) Floating leaf Association.

Nelumbium speciosum (often dominant)
Nymphaea stellata
Limnanthemum cristatum
„ indicum
Potamogeton spp.
Lemna spp
Ottelia alismoides
Limnophila racemosa
Pontederiaceæ sp.
Jussieua repens } Floating stems
Ipomæa reptans } Floating stems
Marsilea sp.
Azolla sp.

(3) Reed swamp Association.

Eleocharis congesta (often dominant)
Cyperus spp.
Typha sp.

CAESALPINIA BONDUCELLA Fleming.

BY T. PETCH, *Peradeniya, Ceylon.*

Though this plant is said to be common on sea coasts round the tropics, the evidence for its occurrence in Ceylon has hitherto rested solely upon specimens collected by Hermann in the seventeenth century.

Hermann collected three specimens, for which he gave the Sinhalese name Kumburu-wel. The first of these is enumerated in Musæum Zeylanicum, p. 12, as "Kuburuwael. Lobus echinatus Clusii fructu albo. Lusitani oculos cati et felis vocant. Fructus ex lobis suis eruti Elephantorum pabulum fiunt. Pronunciatur Kumburuwael." The second was recorded on page 19 as Kuburuwael with the reference, "*Vide* Volume I. fol. 68," *i.e.*, to the first specimen. The third, on page 57, is "Kuburuwael. Lobus echinatus Clusii, Oculos Cati Lusit. Fructus ex lobis suis exuti elephantum pabulum fiunt." "Lusitani" refers to the Portuguese in Ceylon.

Hermann gave the same Sinhalese name for all three specimens, *viz.*, Kumburu-wel. That is the Sinhalese name of *Caesalpinia Bonduc* Roxb.

Linnaeus, in Flora Zeylanica, separated Hermann's three specimens into two species. Flora Zeylanica No. 156 being Hermann 12 and 57, and Flora Zeylanica No. 157, Hermann 19.

Flora Zeylanica No. 156 was "Guilandina aculeata, foliolis ovalibus cum acumine." The description is "Rami medulla fungosa, subvillosi. Folia duplicato-pinnata, foliolis ovalibus, obtusis cum acumine seu seta, in singulo partiali, 6, 7, vel 8 parium. Flores in racema sive spica, calyce tomentoso, masculi; femineos non vidi."

Flora Zeylanica No. 157 was "Caesalpinia aculeis recurvis, foliolis ovatis." The description is "Rami lignosi, solidi, glabri. Folia duplicato-pinnata, foliolis ovatis, glabris (absque acumine setaceo), in singulo partiali folio 3 paria remota. Floris glabri, in racemis laxioribus magis labiati. Fructus Guilandinae."

In Species Plantarum, Ed. II, 545, No. 156 is *Guilandina Bonducella*, and in Mant. II, 378, No. 157 is *Guilandina Bonduc*.

In 1857, the plants of Hermann's Musæum Zeylanicum were examined by W. Ferguson, who made notes which are still in Mss. With regard to Flora Zeylanica No. 156, he wrote "Ic. good, showing

swelled three-fruited pods. It is the round-seeded one that strikes fire (?). Leaves oval mucronate"; and with regard to No. 157, "This is *Caesalpinia paniculata* W. & A. A very different plant from the above." *Caesalpinia paniculata* W. & A. = *Caesalpinia Nuga* Ait. It is noteworthy that Ferguson considered that he recognised the plant of Flora Zeylanica, No. 156.

Trimen examined these plants in 1886, and published an account of them under the title "Hermann's Ceylon Herbarium and Linnaeus' Flora Zeylanica" in Jour. Linn. Soc., XXIV, pp. 129–155. He found that No. 157 was *Caesalpinia Nuga* Ait., thus confirming Ferguson, and passed No. 156 as *Caesalpinia Bonducella* Flem., adding the note, "*Caesalpinia Bonducella* has not been recently recorded for Ceylon, though *C. Bonduc* is common."

The Dutch held only the Maritime Provinces of Ceylon, and Hermann could collect only in the neighbourhood of the coast from Negombo to Matara. Those districts have since been explored by every botanist who has collected in Ceylon, both in Dutch and British times, but none of them collected *Caesalpinia Bonducella*. Moon cites the name in his Catalogue, and gives Kalutara as a locality, but unfortunately that is not evidence that he saw it. It is not generally recognised, although Moon stated the fact clearly in his preface, that the names which he enumerated fall into three categories, *viz.* (1) plants which had been recorded previously, (2) known plants recorded for Ceylon for the first time, and (3) new names proposed by Moon. These are indicated by different type or by the addition of the letter M. In compiling his list, Moon began by extracting from Willdenow, Species Plantarum, all the names of plants recorded for Ceylon. There is no reason to suppose that Moon knew the plants indicated ; in fact, there is ample reason to suppose that he did not, as in some cases he lists the same plant under different names in all three categories. *Guilandina Bonducella* is one of the names which Moon obtained from Willdenow. It may be objected that as Moon gave a locality for the plant (Kalutara) he must have known it and collected it. That objection, however, falls to the ground when his list is considered in detail. For example, he cited Kalutara as a locality for *Chionanthus zeylanica* Lam. and gave a Sinhalese name for that plant. But the plant so named is an American species, *Chionanthus virginicus*, which had been recorded for Ceylon in error. Moon's evidence is consequently untrustworthy. Kalutara, indeed, appears to have been Moon's stock locality for plants he enumerated but did not know.

Accepting the identifications and localisation of the specimens in Hermann's herbarium as correct, we have two remarkable facts.

First, that Hermann did not obtain any specimen of *Caesalpinia Bonduc*, which is common in the district he worked over; and secondly, that he did collect two specimens of a closely-allied species which eluded all who followed him. Both these facts appeared so highly improbable that Hermann's record has been considered doubtful. Trimen included *Caesalpinia Bonducella* in the Handbook of the Flora of Ceylon in a note only, evidently not regarding it as a Ceylon plant; and Willis omitted it from his Catalogue of the Flowering Plants and Ferns of Ceylon.

In February, 1922, J. Miguel Silva, the plant collector attached to the Perandeniya Herbarium, was commissioned to search especially for *Caesalpinia Bonducella* in the Kalutara district, and succeeded in finding examples at Dehiwela and Biyagama. The plant must consequently be re-instated in the Ceylon list.

The case is a very interesting one, as illustrating the value of probabilities in connection with field investigation in botany. It was considered highly improbable that Hermann should have collected for several years in a district in which *Caesalpinia Bonduc* is common, without obtaining that species. Yet some how he managed to do it. And it was also considered improbable that he should have collected two examples of an allied species, *Caesalpinia Bonducella*, which no one had been able to find since. The fact that one of the three collections was incorrectly named, obviously favoured the suggestion that the other two had also been misnamed and were probably the common *Caesalpinia Bonduc*. But the evidence of the specimens disproves these assumptions, and the rediscovery of *Caesalpinia Bonducella* in Ceylon confirms Hermann's record.

A NEW SCIAPHILA.

By T. Petch, *Peradeniya, Ceylon.*

Three species of *Sciaphila* were recorded for Ceylon in Trimen's Flora. All of them are rare, and occur in the forests of the wet low-country.

Another species was found in February, 1923 in the jungle at Hakgala, Ceylon, at an elevation of 5600 ft. Specimens were found in several localities, the distance between the extreme stations being about two miles. Hence it may be expected to be generally distributed through the jungle of that region. It is not, however, easy to find. The whole of the plant above ground is a dark reddish purple, and consequently inconspicuous; and it occurred principally along the exposed lateral roots of large trees, where it was usually almost completely covered with dead leaves.

Of the other Ceylon species, it is most closely allied to *Sciaphila secundiflora* Thw., a species which has been collected only in one locality in the low-country, and not since 1855. The latter differs in having long, subulate perianth segments and a penicilliate stigma. The new species resembles *Sciaphila sumatrana* Becc., which however, is white, has a penicilliate stigma, and a style shorter than the ovary.

On the specimens collected, male flowers are very scarce, usually one or two about the middle of the inflorescence. They soon fall off. The ripe female flower may consist of as many as fifty succulent carpels.

Sciaphila inornata Petch, n. sp.; affinis S. sumatranæ Becc., a qua differt colore purpureo, stylis ovarium excedentibus et non penicilliatis.

Planta tota purpurea, simplex, ad 10 cm. alta. Bractæ late ovatae, acutae, ad 3 mm. longae, 2 mm. latae. Flores racemosi, subalternati, pauci (ad 10), 5 mm. diametro, unisexuales, pedicellis suberectis, ad 5 mm. longis, vivo crassis masculi paucissimi, in medio racemi. Perianthii segmenta utriusque sexus 6, ovata vel lanceolata, acuta, glabra, inappendiculata, celluloso-bullata. Flores masculi triandri; antherae sessiles; pistillodia nulla. Flores feminei carpellis maturis 5 mm. diametro, perianthii segmenta reflexa: staminodia nulla; ovaria apice tuberculata; stylus fere basilaris, clavatus, simplex, apice subacuto, ovarium excedens.

THE FLORA OF SIND.

BY

T. S. SABNIS, B.A., M.Sc.

Continued from page 206.

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4. ABUTILON *Tournef.*

1. **Abutilon indicum** *Sweet Hort. Brit. I (1827) 54.* Loc. :—Karachi " Jamadar ka Landa (9) ".

Distribution :—Baluchistan, Tropics generally.

2. **Abutilon muticum** *Sw. Hort. Brit, ed. 2 (1830) 65.* Loc. : Karachi " Magho Pir (9) ". Nawabashah : Pad Idan (Sab. B. 495 !). Hyderabad : Ganja hill (Sab. B. 987 !) ; Phuleli canal banks (Sab. B 155 !, B 185 !, B 196 !). Thar and Parkar : Nasarpur (Sab. B 1135 !) ; Mirpurkhas (Sab. B 864 !, B 1037 !) ; Jamesabad (Sab. B 929 !, B 1158 !) ; Sanghar (Sab. B 630 !) ; Umerkot, Sandy plains (Sab. B 935 !).

Distribution :—Trop. Africa, Egypt, Afganistan, India. Fl. and Fr. :—October and November.

3. **Abutilon graveolens** *Wt. et. Arn. Prodr. (1834) 56.* Loc. :—Larkana : " Sehwan (9) ".

Distribution :—Extends from Trop. Africa to Queensland.

4. **Abutilon ramosum** *Guill, Perr. et. A. Rich., Fl. Senegamb. I (1830) 68.* Loc. :—Karachi : " Karachi (9) ".

Distribution :—Trop. Africa, Arabia.

5. **Abutilon fruticosum** *Guill., Perr. et.* A. *Rich., Fl. Senegamb. I (1930) 70.* Loc. :—Karachi : " Jamadar ka Landa (9) "; " Malir (9) ".

Distribution :—Trop. Africa, Arabia, Baluchistan, Java.

6. **Abutilon cornutum** *T. Cooke. Fl. Bom. Pres. I,98.* Loc. :—Karachi : " Maghe Pir (9) ". Without locality (9).

5. PAVONIA *Cav.*

1. **Pavonia arabica** *Stend. Nom. ed. 2, (1841): 279.* Loc. :—Karachi : " Karachi (9) ", without locality (9).

Distribution :—Abyssinia, Baluchistan, Rajputana.

2. **Pavonia zeylanica** *Cav. Diss. 3 (1787) 134, t. 48, fig. 2,* Loc. : —Karachi : " Jamadar ka Landa (9) ". Without Locality (9).

Distribution :—Trop. Africa, Mauritius, India, Ceylon.

3. **Pavonia ceratocarpa** *Mast. in Fl. Brit. Ind. I (1874) 331.* Loc. :—Karachi : " Karachi (9) ". Without locality (9).

4. **Pavonia propinqua** *Garcke in Schweinf. Fl. Aethiop.* I *(1867) 55.* Loc. :—Without locality (9).

Distribution :—Abyssinia, Baluchistan.

6. SENRA *Cav.*

1. **Senra incana** *Cav. Diss. 2 (1786) 83, t. 35, fig. 3 (Serra) 104 (Senra).* Loc. :—Karachi : " Moach, very abundant (9) " ; " Jamadar ka Landa (9) " ; Gizri sands (Sab. B 779 !) ; Manora Isl. (Sab. B 822 !). Without Locality (9).

Distribution :—Nubia, Abyssinia, Arabia, Fl. and Fr. :—October.

7. HIBISCUS *L.*

1. **Hibiscus trionum** *L. Sp. pl. (1753) 687.* Loc. :—Without locality (9).

Distribution :—Southern Europe, Baluchistan, Tropics of the Old World.

2. **Hibiscus micranthus** *L. f. Suppl. (1781) 308.* Loc. :—Karachi : Karachi (Ticehurst 28132 !, 32262 !). Larkana : Laki hill (Ticehurst 28115 !). Thar and Parkar : Umerkot, fields (Sab. B 1192 !). Without locality (9).

Distribution :—Trop. Africa, India, Ceylon. Fl. :—August—November.

3. **Hibiscus sindicus** *Stocks in Hook. Ic. pl. (1852) t. 802.* Loc. :—Karachi : " Jamadar ka Landa (9) ". Without locality (9).

Distribution :—Baluchistan.

4. **Hibiscus intermedius** *A. Rich. Tent. Fl. Abyss. 1 (1847) 58.* Loc. :—Without locality (9).

Distribution :—Trop. Africa, Arabia.

5. **Hibiscus cannabinus** *L. Syst. Nat. (1759) 1149.*

Vern. Name : Ambadi. Loc. :—Larkana : Laki, foot of the hill (Sab. B 531 !, B 78 !). Thar and Parkar : Umerkot, garden (Sab. B 730 !).

Distribution :—Cultivated in most tropical countries. Fl. and Fr. : October and November.

6. **Hibiscus punctatus** *Dalz. in Dalz. and Gibs. Bomb. Fl. (1861) 20.* Loc. :—Karachi : " Karachi (9)" " Jamadar ka Landa (9)". Thar and Parkar Mirpurkhas, fields (Sab. B 1188 !) ; Jamesabad (Sab. B 966 !) ; Umerkot,—" garden (Sab. B 732 !), sandy plains (Sab. B 1087 !).

Distribution :—Gujarat. Fl. and Fr. ; October and November.

8. THESPESIA *Soland ex Corr.*

Thespesia populnea *Soland ex Corr., in Ann. Mus. IX (1807) 290. Vern. Name*: Bhendi. Loc.: Karachi: Manora Isl. (Sab. B 815). Distribution :—Africa, Trop Asia, the Pacific islands.

9. GOSSYPIUM *L.*

1. **Gossypium Stocksii** *Mast. in Hook. f. Fl. Brit. Ind. I (1874) 346.* Loc. :—Karachi: "Moach very abundant (9)". Without locality (9).

2. **Gossypium arboreum** *L. Sp. pl. (1753) 693.*—Var. I neglectum. Loc.:—Nawabashah: Pad Idan (Sab. B 565 !). Thar and Parkar: Mirpurkhas (Sab. B 696 !).

Distribution :—Cultivated in parts of Deccan, but more extensively in Bengal, Central India, Rajaputana and N. W. Provinces, as a field crop. Fl. and Fr.: October and November.

10. BOMBAX *L.*

Bombax Malabaricum *Dc. Prodr. I (1824) 479.*

Vern. Name: Savar. Loc :—Sukkur, Sykkur, forest nursery (Sab. B 432 !).

Distribution :—Konkan, Deccan, Java, Sumatra.

XVI. Sterculiaceae.

1. MELHANIA *Forsk.*

1. **Melhania abyssinica** A. *Rich. Tent. Fl. Abyss. (1847) I,76.* Loc. :—Without locality (9).

Distribution :—Abyssinia, Cape Verd Islands.

2. **Melhania tomentosa** *Stocks ex. Mast. in. Hook. f. Fl. British India 1,373.* Loc.: Without locality (9).

Distribution :—The Punjab, Gujarat.

3. **Melhania Denhami** *R. Br. in. Denh. and Clapp. Trav. (1826) App., 232.* Loc.: Karachi: "Karachi, hills (9)". Without locality (9).

Distribution :—Trop. Africa, Arabia, Baluchistan, Rajputana.

XVII. Tiliaceae.

1. GREWIA *L.*

1. **Grewia populifolia** *Vahl. Symb. I (1790) 33.* Loc. :—Karachi: Karachi (Ticehurst 28144 !). Thar and Parkar: Jamesabad (Sab. B 1100 !); Sanghar (Sab. B 773 !); Umerkot, sandy plains (Sab. B 944 !). Without locality (9).

Distribution :—Trop. Africa, Arabia, S. Persia, Afganistan, Baluchistan, S. M. Country, Ceylon, Mauritius.

2. **Grewia salvifolia** *Heyne ex Roth. Nov. pl. Sp., 239 (1821).* Loc. :—Without locality (9).

Distribution :—Trop. Africa.

3. **Grewia asiatica** *L. Mantiss, (1767) 122.* Loc. :—Karachi "Jamadar ka Landa (9)." Without locality (9).

Distribution :—East Trop. Africa.

4. **Grewia villosa** *Willd. in Ges. Naturf. Fr. IV (1803) 205.* Loc. :—Karachi : Soorjana hills 1800 ft. (Ticehurst 30878 !) ; "Karachi (9)" Without locality (9).

Distribution :—Trop. Africa, India.

2. Corchorus *L.*

1. **Corchorus olitorius** *L. Sp. pl.: (1753) 529.* Loc.:—Sukkur: fields (Sab. B 528 !). Thar and Parkar : Mirpurkhas (Sab. B 1173 !); Jamesabad, fields (Sab. B 1146 !) ; Sanghar (Sab. B 765 !) ; Umerkot, garden (Sab. B 720 !, B 731 !). Without locality (9).

Distribution :—All Tropical regions. Fl. and Fr. : October and November.

2. **Corchorus trilocularis** *L. Mant. (1767) 529.* Loc. :—Larkana : Larkana, coloured soil (Sab. B 94 !) ; Laki, foot of the hill (Sab. B 9 !). Sukkur : Sukkur, fields (Sab. B 530 !). Hyderabad : Phuloli canal banks (Sab. B 340 !) ; Hyderabad, rocky plateau (Sab. B 257 !). Thar and Parkar : Mirpurkhas (Sab. B 1181 !); Jamesabad, fields (Sab. B 1148 !); Sanghar (Sab. 629 !, B 636 !).

Distribution :—Trop. Africa, Afganistan, India. Fl. and Fr.; October and November.

3. **Corchirus Antichorus** *Raeasch. Nom. ed. 3 (1797) 158.* Loc. ;—Larkana : Larkana, coloured soil (Sab. B 91 !, B 493 !) ; Sehwan, clayey soil (Sab. B 164 !). Khairpur : Khairpur, clayey soil (Sab. B 354 !). Hyderabad : Hyderabad, "(9)", rocky plateau (Sab. B 253 !, B 239 !); Kotri, Indus banks (Sab. B 390 !). Thar and Parkar : Nasarpur (Sab. B 1133 !); Mirpurkhas, water course (Sab. B 879 !, B 1189 !), fields (Sab. B 697 !) ; Sanghar (Sab. 632 !, B 651 !). Without locality (9).

Distribution :—Cape Verd Islands, Trop. Africa, Arabia, Afganistan, India. Fl. and Fr. : October and November.

4. **Corchorous tridens** *L. Mant. App. (1771) 566.* Loc. :—Thar and Parkar : Sanghar (Sab. B 750 !). Without locality (9).

Distribution :—Trop. Africa, India, Australia. Fl. and Fr. : November.

5. **Corchorus acutangulus** *Lam. Encycl. II* (*1786*) *104*. Loc. :— Karachi: "Jamadar ka Landa (9)". Sukkur: Sukkur, fields (Sab. B 529 !). Khairpur: Mirs forest (Sab. B 333 !).

Distribution :—Trop. Africa, India, Ceylon, Australia, West Indies. Fl. and Fr.: October and November.

XVIII. Zygophyllaceae.

1. TRIBULUS *L.*

1. **Tribulus terrestris** *L. Sp. pl.* (*1753*) *387*.

Vern. Name: Gokhru, Sarata. Loc. :—Karachi: "Jamadar ka Landa (9)". Larkana: Laki, foot of the hill (Sab. B 116 !). Khairpur: Khairpur, clayey plain (Sab. B 346 !). Thar and Parkar: Mirpurkhas, water course (Sab. B 847 !, B 1035 !). Without locality (9).

Distribution :—All warm regions. Fl. and Fr.: October and November.

2. **Tribulus alatus** *Del. Fl. Aegypt. Arab. III.* (*1812*) *62*. Loc. :— Larkana: Sehwan, "(9)", clayey soil (Sab. B 601 !). Thar and Parkar: Sanghar (Sab. B 627 !). Without locality (9).

Distribution :—N. Africa, Arabia, Rajputana. Fl. and Fr.: October and November.

2. SEETZENIA *Br.*

1. **Seetzenia orientalis** *Dcne. in Ann. Sc. Nat. ser. 2, III* (*1835*) *281*. Loc. :—Larkana: "Hala (Kirthar) range (9)"; "Laki (9)" Without locality (9).

Distribution :—N. & S. Africa, Arabia, Rajputana.

3. PEGANUM *L.*

1. **Peganum Harmala** *L. Sp. pl.* (*1753*) *444*. Loc. :—Hyderabad: Hyderabad, "(9)", rocky plateau (Sab. B 238 !). Thar and Parkar: Mirpurkhas, fields (Sab. B 709 !). Without locality (9).

Distribution :—India to Arabia, N. Africa, Mediterranean. Fl. and Fr.: October and November.

4. ZYGOPHYLLUM *L.*

1. **Zygophyllum simplex** *L. Mantiss. I* (*1767*) *68*. Loc. :— Karachi: "Karachi (9)"; Manora Isl (Sab. B 842 !); Magho Pir (Sab. B 208 !). Larkana: "Hala (Kirthar) range (9)". "Hyderabad: Ganja Hill (Sab. B 998 !). Thar and Parkar: Jamesabad fields (Sab. B 1098 !). Without Locality (9).

Distribution :—Trop. Africa, W. Asia, Rajputana. Fl. and Fr. :—October and November.

2. **Zygophyllum coccineum** *L. Sp. pl.* (*1753*) *386*. Loc. :—Larkana : Sehwan—sand dunes (Sab. B 676 !, B. 677 !), coloured soil (Sab. B. 599 !), rocky plateau (Sab. B. 672 !) ; Laki, foot of the hill (Sab. B 82 !), Hyderabad : Hyderabad, rocky plateau (Sab. B 240 !) ; Ganja Hill (Sab, B 995 !). Thar and Parkar : Mirpurkhas, water course (Sab. B 882 !). Without locality (9).

Distribution :—Egypt, Syria, Arabia, Baluchistan.

Note.—Very common in countries west of the Indus.

5. FAGONIA *L.*

3. **Fagonia cretica** *L. Sp. pl.* (*1753*) *386*. Loc. :—Karachi : Cizri (Sab. B 782 !) ; Clifton (Sab. B 793 !, B 804 !) ; Magho Pir (Sab. B 210 !). Laki, Hill-top (Sab. B 121 !). Hyderabad, Ganja hill (Sab. B 992 !). Thar and Parkar : Nasarpur, sandy plains (Sab. B 1061 !) ; Mirpurkhas, water course (Sab. B 867 !) ; Jamesabad, fields (Sab. B. 970 !, B 1115 !) ; Umerkot, sand dunes (Sab. B 1014 !). Without locality (9).

Distribution :—Both shores of the mediterranean, S. Extra Trop. Africa, warmer dry parts of Asia, Western N. and S. America. Fl. and Fr. : October and November.

XIX. Geraniaceae.

1. MONSONIA *L.*

1. **Monsonia senegalensis** *Guill. and Perr. Fl. Seneg. Tent. I* (*1830*) *131*. Loc. :—Karachi : " Jamadar ka Landa (9) ".

Distribution :—Senegambia, Arabia, Baluchistan, Rajputana.

2. **Monsonia heliotropioides** *Boiss. Fl. Orient. 1* (*1867*) *897*. Loc. :—Karachi : " Thano. Bula-khan, 51 miles from Karachi (9) ".

Distribution :—Rajputana, Westwards to Egypt.

2. ERODIUM *L'Herit.*

1. **Erodium cicutarium** *L'Herit ex. Ait. Hort. ed. 1, II* (*1789*) *414*. Loc. :—Karachi : " Tatta (9) ".

Distribution :—Throughout Europe and temperate N. Asia, Baluchistan, Rajputana.

(*To be continued.*)

A NOTE ON THE GENUS BUTEA

BY

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The genus Butea as defined by Bentham in 1865 (Gen. Pl. Vol. I, p. 533.) and by Taubert in 1894 (Nat. Pflanzenfam. Vol. III, 3 p. 365) is said to contain 2 ovules in the ovary. Prain also in his revision of the genus (Kew Bull. 1908, p. 385) gives the number of ovules as 2. All the floras so far as they have been seen, including the Flora of British India, also describe the ovary as 2-ovuled. Beddome however, in his Fl. Sylv. t 176 shows 6 ovules, although in the generic characters he states that the ovules are 2.

Recently while examining flowers of *Butea frondosa* Roxb., 4 ovules were noticed in the ovary and in order to be certain that this was not an abnormality a large number of flowers from different trees was examined. The result proved very interesting as it showed that the ovary in *Butea frondosa* Roxb. is never 2-ovuled. The number of ovules was found to vary from 4 to 7. In the great majority of cases, however, only 4 ovules were found, while less frequently 5, and in rare cases 7 ovules could be seen in the ovary.

Subsequently flowers of the following species of *Butea* were examined. The result is as follows :—

1. *Butea superba* Roxb.	4 ovules
2. *B. minor* Ham.	2 ovules
3. *B. pellita* Hook. f.	Do.
4. *B. paviflora* Roxb.	Do.

Thus *B. frondosa* Roxb. and *B. superba* Roxb. agree in having 4 ovules in the ovary, while the remaining species have only 2 ovules. This difference in the number of ovules together with other differences between *B. frondosa* Roxb. and *B. superba* Roxb. on one side, and *B. minor* Ham., *B. pellita* Hook f. and *B. parviflora* Roxb. on the other, makes a brief consideration of the status and limits of *Butea* desirable.

The genus *Butea* was originally published by Roxburgh (Pl. Corom. Vol. I. p. 21) in 1795 to include *B. frondosa* and *B. superba*. In 1814 he admitted a third species *B. parviflora* (Hort. Beng. p. 53) which closely agrees with *B superba* Roxb. in habit and foliage. It

differs however in the colour and size of the flowers, the character of and relationship between the different petals and in the inflorescence being a panicle instead of a raceme, and has for these reasons been referred to another genus *Spatholobus* by various authors.

Butea minor Ham. in Wall. Cat. 5439 which in 1845 was made the basis of the genus *Meizotropis* by Voigt (Hort. Suburb. Calcutta p. 239), and *B. pellita* Hook. f. in Kew Bull. 1908, p. 385 have since been added to the genus. This latter species has been referred to section *Meizotropis* of *Butea* by Prain (Kew Bull. 1908, p. 384).

In 1908 Prain (l. c. p. 385) on the discovery of *B. pellita* Hook f. reviewed the whole genus and in discussing the diverging views as to the status and limits of *Butea* Koen. (based on *B. superba* and *B. frondosa*), of *Meizotropis* Voigt. (based on *B. minor*), and of *Spatholobus* Hassk. (to which *B. parviflora* has been referred) wrote as follows :—

" That while Meizotropis agrees with *Butea*, in which it is included by Bentham and Taubert, as regards colour of petals, it agrees better with *Spatholobus*, which Bentham and Taubert refer to another subtribe, as regards the shape and relationship of the wings. Since the characters to be derived from the corolla are insufficient to warrant the generic separation of *Meizotropis* from *Butea*, they must be equally inadequate to warrant the generic separation of *Spatholobus* from the widened *Butea* in which *Meizotropis* is merged. The segregation of *Spatholobus* is so convenient that its perpetuation is desirable but it has to be recognised that this segregation depends entirely on a difference of facies resulting from the possession of a greater number of smaller and differently coloured flowers, and is unsupported by any morphological character."

The difference in the number of ovules between the two sections of *Butea* (*Eubutea* and *Meizotropis*) into which the genus *Butea* has now been divided, is an additional point and may be of sufficient importance to warrant the separation of *Meizotropis* from *Butea*. If *Meizotropis* is not separated from *Butea* but only given a sectional rank within it, it seems reasonable to accord a similar rank to *Butea parviflora* as a subsection of *Butea* owing to the close resemblance between them. In fact the resemblances are more marked between *Meizotropis* and *Spatholobus* than between *Meizotropis* and *Eubutea*.

The grouping indicated above has already been adopted by Haines in his Botany of Behar and Orissa, Pt. III (1922) p. 279. This arrangement however involves merging the genera *Spatholobus* and *Meizotropis* into *Butea*; the only reasonable alternative seems to be to treat all three as separate genera.

Letter to the Editor

On "Mixed Formations in Time"

DEAR SIR,

I was very much interested in Mr. Saxton's article, "Mixed Formations in Time", which appeared in the December Journal. His idea of the difficulty in classifying Indian habitats because of the extremes of humidity is one that impressed me from the outset of my work in India. However it seems to me we might consider it not a difference in kind from the habitats in the temperate west and requiring a fundamentally different terminology, but a difference in degree, merely placing emphasis upon a truth practically everywhere existing but likely to be overlooked.

An oak forest may be to a large extent a violet society in the spring, an aralia society in midsummer and an aster society in autumn. Yet we designate it by the oak, a plant which is evident all year. Even this plant, as winter comes on, assumes a decidedly more xerophytic aspect.

A xerophytic or hydrophytic habitat, in changing to mesophytic, never moves in a straight line. There is a seasonal rhythm, and to a lesser extent a diurnal rhythm, in the humidity of the environment and in the response of vegetation to this factor. This rhythm is accentuated in a climate like that of the plains of India, nevertheless back of rhythm should be the steady progress toward mesophytism. The swamp tends to become drier each succeeding wet season, while the dry exposure will find succeeding dry seasons less unfavorable for plant life.

The pronounced rhythm in India obscures the course of succession and renders more difficult the reading of the ecological story. For example, a pond changes its level so quickly that it usually does not have the relatively permanent zonation which we find in a pond of the temperate zone. There is a zonation, to be sure, but it is temporary, being made up largely of short-lived forms, and adjusting itself rapidly to the rapidly changing water level.

When a given formation includes plants with perennating organs, might not these be taken as the type plants in naming the formation? When these are lacking, recourse would need to be had to the species that are most conspicuous when vegetation is at its height. An oak forest is termed mesophytic, from the relation to humidity when at its period of greatest vegetative activity, although it is decidedly xerophytic at certain seasons. Could not the same considerations be used in naming Indian plant formations?

Sincerely yours,

L. A. KENOYER.

MICHIGAN AGRICULTURAL COLLEGE,
EAST LANSING,
Botany Department, *March* 17, 1923.

CURRENT LITERATURE.

Algae.

Groves, James. Notes on Indian Charophyta. *Read before the General Meeting of the Linnean Society of London, 3rd May, 1923.*

The author stated that it was seventy-four years since a separate account of the Indian charophytes had appeared and that at that time eleven species only were known to occur. A few additional records were published in 1873, and in the "Fragmente einer Monographie der Characeen" compiled by Dr. Nordstedt from Braun's MS., and published in 1882, a number were added. Since the last date much collecting had been done and the present paper was the result of the examination of specimens which had passed through the hands of the late Henry Groves and the author. Mr. Groves emphasized the necessity of the study of some of the more variable species on the spot, it being often impossible to arrive at a satisfactory conclusion from the single specimen frequently badly preserved which was often all that was available on this side. In 1882 representatives of the genera *Chara* and *Nitella* only were known from India. He was now able to record a *Nitellopsis*, a *Lychnothamnus* and three species of *Tolypella*. The paper included descriptions with figures of two new species, *Nitella Watti* and *N. mirabilis* (previously found in China, and named in MS. by Dr. Nordstedt). That much was still to be done in this group was evident from the fact that Mr. G. O. Allen (who was present) had within the past three years, in a comparatively small area, added three well-marked species to the Indian flora besides rediscovering *C. Wallichii*, of which only the male plant collected in 1809 by Dr. Wallich was previously known, and establishing the occurrence of *Nitellopsis obtusa* (in Kashmir) the only previous Asiatic record of which was dependent on a poor specimen from Burmah, as to which, owing to its sterility, there had been an element of doubt.

Cytology of the Cyanophyceae.

Haupt, Arthur W. Cell structure and cell division in the Cyanophyceæ. *Bot. Gaz. 75: 170-190. 1 pl. 1923.*

The Cyanophyceæ are regarded as the most primitive group of autotrophic plants. Their primitive cell structure has been regarded by many investigators as representing an early stage in cell evolution. Despite the work of about 50 investigators there still is diversity of opinion concerning the details of cell structure and division, and the interpretation of these details. Haupt has brought the most modern cytological methods to bear on the problem. Out of a number of forms, *Anabaena circinalis* Rabenhorst and *Glœocapsa aeruginosa* (Carm.) Kg. were chosen for intensive study; the former shows details of structure unusually clearly.

The protoplast of the Cyanophycean cell consists of undifferentiated, finely-granular, highly vacuolated cytoplasm, without any definite "central body" or nucleus at the centre, or chromatophore at the periphery. The

so-called chromatophore is merely the outer portion of the cytoplasm containing pigments in solution, probably in the vacuoles. There are no organized chromatophores. Most cells contain cyanophycin granules (reserve food) at the margin. In the central portion of the cell is a deeply staining substance "which forms stringlike masses resembling chromosomes" but whether they actually are chromosomes, or whether they even consist of chromatin remains undecided. There is no organized nucleus and "no evidence that a 'central body' exists as an independent organ of the cell".

At cell division the central substance stretches out and constricts into two approximately equal masses. This is held to be strict amitosis. There is no indication of any of the complicated processes that characterize mitosis in higher plants, no definite chromosomes, no longitudinal splitting, no spindle fibres. While the central substance is dividing, a ringlike wall gradually develops centripetally and constricts the cytoplasm into two parts.

The conclusion is that ' The Cyanophycean cell is organized without the differentiation seen in the cells of higher plants. A slight functional differentiation is displayed in the restriction of photosynthetic activity to the peripheral region of the cell, and in the presence of a substance in the center of the cell which is transmitted through successive generations."

It would be interesting to apply modern methods for the study of mitochondria to the cells of Cyanophyceæ. Recent work suggests that many of the older conceptions of cell structure and cell division are erroneous, because based on methods that destroy the mitochondria and thus alter the actual structure of the cell. The full significance of mitochondria is still unknown; it is quite possible that they may constitute an important part of the Cyanophycean cell, and that when studied from this point of view the true structure and interpretation of the cell of Cyanophyceæ will be revealed.

WINFIELD DUDGEON.

Pathology.

Nelson, Ray. The occurrence of protozoa in plants affected with mosaic and related diseases. *Michigan (U. S. A.) Agric. Coll. Exp. Sta. Tech. Bull. 58, p. 1–28, 18 fig, December, 1922.*

Mosaic diseases are destructive to a wide range of cultivated plants, The cause of the disease has been variously attributed to enzymes, bacteria. filterable virus and lately to protozoa. But hitherto, as the author states. "no definite organisms have been demonstrated in the tissues of any plant affected with mosaic or the closely related diseases," although since 1910 protozoa have been connected with other types of disease in a few plants.

Mosaic disease can be transmitted by contact, by inoculation with expressed juice of affected plants, and by sucking insects. The fact that these insects take their food from phloem tissues led Nelson to do what apparently had not been done before—to make a careful cytological search for organisms in the phloem, by means of microtomed *longitudinal* sections, Bean, tomato, and clover mosaic, and potato leaf-roll were studied intensively, using protozon killing and fixing reagents, and iron-alum hæmatoxylin stain. He found "definite protozoan organisms . . . to be constantly asso-

ciated with these diseases," and believes that only the use of tranverse sections prevented other investigators from discovery of the organisms years ago.

The organisms usually lie parallel to the long axis of the sieve tubes and phloem parenchyma cells, in contact with the nuclei. Ultimately the nuclei seem to be injured or even destroyed. The bean and clover organism is an elongated bi-flagellate protozoan, somewhat resembling *Leptomonas*, and probably representing a new genus. The tomato mosaic and potato leaf-roll organisms appear to be trypanosomes. All these organisms exhibit great polymorphism. Further study along several lines is in progress.

WINFIELD DUDGEON.

Ecology.

Osmaston, A. E. Notes on the Forest Communities of the Garhwal Himalaya. *The Journal of Ecology 10; 129—167. Plates 8—14, November, 1922.*

A welcome contribution to the plant ecology of India has been made by Mr. Osmaston through this paper. The many observations made during ten years of service in the government forestry work have been put on record in such a way as to be of real significance toward the solution of the interesting problems of distributional and dynamic ecology in the Himalayas. Our forest officers have a unique opportunity for advancing our knowledge in this modern phase of botanical development in what is in many ways a unique area, and it is to be hoped that others of them will emulate Mr. Osmaston's example.

The author on the basis of estimated rainfall divides the region treated, viz., that part of the district beyond the Nayar River, into four zones,—the moist, dry, arid, and Tibetan, having respectively about 40—80, 15—40, 10—15 and 0—10 inches of rainfall per year. In these zones he recognizes five formations sub-divided into associations as follows, passing from higher to lower altitudes :

I. Caragana-Lonicera-Artimesia Formation.
  1. Caragan-Artimesia Association.
  2. Salix-Myricaria Association.

II. Betula-Rhododendron Formation.
  1. Rhododendron-Lonicera Association.
  2. Betula-Abies Association.

III. Pinus-Cedrus Formation.
  1. Pinus-Cedrus Association.
  2. Hardwood Association.

IV. Quercus-Abies Formation.
  1. Quercus-Abies Association.
  2. Quercus-Acer Association.

V. Shorea-Anogeissus-Pinus Formation.
  1. Pinus longifolia Association.
  2. Anogeissus latifolia Association.
  3. Softwood Association.

He discusses at some length these formations and associations together with their included consociations and those species which cover large enough areas to constitute societies. He gives much valuable information concerning the altitudinal ranges of the various species, more than a hundred of which are separately treated.

He finds the first formation peculiar to the Tibetan zone, while the fourth is practically limited to the moist zone. The manner in which some of the other formations overlap the moist, dry, and arid zones, however, would seem to cast some doubt on the value of his division into zones. He does not explain the basis on which rainfall is estimated, but surely the zones of equal precipitation would not extend in nearly so direct lines across ranges and valleys as his map indicates; they would be influenced to a considerable extent by the contour. The rainfall figures given in the Garhwal Gazeteer (Kotdwara 69 in., Pauri 50 in., Srinagar 35 in., Ukhimath 61 in.) would certainly indicate that hilltops and outward slopes receive more rain than valleys even though they may be further from the outer border of the Himalayas. Furthermore to interpret the suitability of the habitat for plants, as the author is of course well aware, the rainfall must be considered in connection with atmospheric humidity, run-off, and character of soil. If this were done, would not the humidity zones correspond more nearly with the vegetation zones?

One thing apparent in the map corresponds to the reviewer's observations in Tehri-Garhwall State. *i.e.* the fact that the oaks are almost lacking from the larger valleys. This is probably because of insufficient humidity. On the upper Bhagirathi, Pinus excelsa comes down from the higher altitudes just far enough to meet the upper limit of Pinus longifolia.

The reviewer, so far as his observations have gone, would question the combination Shorea-Anogeissus-Pinus. He has not seen Shorea at anything like the altitudes occupied by Pinus, a distinct zone of what the author calls the softwood association intervening. Anogeissus is not frequent in the Tehri-Garhwal and Kumaon sections seen by the reviewer, the various Bauhinias being far more characteristic of a broad zone influenced by monsoon conditions. He also feels that in these sections Quercus-Rhododendron would be more fitting than Quercus-Acer as the name of one of the associations.

We would suggest that to guard against confusion it would be well to use the specific names in constructing formation and association terms, when the same genus occurs in different groups, as is the case with Pinus, Quercus and Abies.

The illustrations for the most part represent very well the vegetational types of the region.

L. A. KENOYER.

Notes for Students.

Punnett, R. C., F.R.S. Linkage in Sweet Peas (Lathyrus odoratus). *Journal of Genetics, Vol. 13, No. 1, March 1923.*

The explanation of linkages in the hereditary units of plants and animals has been a subject of controversy for some time past. The fact that the observed linkage systems in Sweet Peas were never complete but broke

down occasionally led Bateson and Punnett[1] to put forward the hypothesis of "Reduplication" as an explanation of "Coupling," and "Repulsion" or "Spurious allellomorphism". The term "Reduplication" is expressive. According to this hypothesis there is no independent inheritance of special combinations of hereditary units but only their duplication at some stage of the development of the Zygote.[2] Consequently, linkage can never be complete. Whenever it was found complete, the adherents of this hypothesis explained it by assuming that non-linked forms would be found if a large number of offsprings were examined in F^2. A further corollary of this hypothesis is that the time and place of segregation of hereditary units is not necessarily restricted to the Reduction division. The peculiar behaviour of chromosomes at the time of the Reduction division might not be the "cause" of segregation but merely a "correlation" or even "consequence".

The brilliant researches of Morgan and his colleagues on linkage systems of hereditary units in Drosophila focussed the attention of genetists on the importance of "Chromosome hypothesis"[3] as an explanation of the linkage phenomena. It now comes as an agreeable surprise that the author of the article under review is also led to the same conclusion on taking stock of the characters in Sweet Peas studied so far, for it is primarily the author's work on Sweet Peas in collaboration with Bateson that led to an enunciation of Reduplication hypothesis.

Accumulation of data of Mendelian heredity in plants requires laborious work for a period of a number of years. The author gives an account of 17 pairs of characters in Sweet Peas showing normal Mendelian inheritance studied over a period of 19 years. He arranges 14 of these under five definite linkage systems representing five different chromosomes. He designates each of these systems with the letters A. B. D. F. and G, respectively, the characters represented in each system being further designated as A^1, A^2, A^3, etc., with their allellomorphic pairs a^1, a^2, a^3, etc. The symbols adopted for different characters in Sweet Peas have thus been overhauled completely. There are three pairs of characters in the linkage system A, four in B, two in D, three in F, and two in G. The relative linear positions of characters in each chromosome are determined by the percentages of cross-overs as usual, except in the case of B^4 where enough data are not yet available, and are

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[1] W. Bateson and R. C. Punnett.—"On gametic series involving Reduplication of certain terms." Journ. Gen. Vol. I No. 4, Nov. 1911, p. 293.

[2] For a further development of the Reduplication hypothesis see:—

(*a*) A. H. Trow—Journ. Gen. Vol. II, No. 4, Feb. 1913, p. 313 (*b*) R. C. Punnett—Journ. Gen. Vol. III. No. 2. Sept. 1913, page 77. (*c*) P. G. Bailey—Journ. Gen. Vol III. No. 3, Feb 1914, p. 221. (*d*) R. C. Punnett—Journ. Gen. Vol, VI. No. 3, April 1917, page 185 and (*e*) Caroline Pellew. Journ. Gen. Vol, VI. No. 4, July 1917, page 317.

[3] For a general survey of chromosome hypothesis, see:—

(*a*) Morgan, Sturterant, Muller and Bridges—"The mechanism of Mendelian Heredity". Constable and Co., Ltd., London, 1915, where an exhaustive bibliography is given.

(*b*) Morgan "Mechanism of Heredity" a series of 3 articles contributed to Nature of February 23, 1923, March 2, 1922 and March 9, 1922.

indicated in the diagram given on page 111. In the F. system of linkage, he also finds evidence of what are termed multiple allellomorphs, the factors for marbled flower, self-coloured flower and one kind of white flower called "R—White" occupying the same locus in the chromosome. With additional evidences for the existence of multiple allellomorphic series, the "presence and absence" hypothesis becomes more and more untenable.

Winge[4] has ascertained that the haploid number of chromosomes in Lathyrus is seven. Besides the fourteen pairs of characters in Sweet Peas which are arranged in five systems of linkage, there are three other pairs designated C, E and H which cannot be referred to any of the above five systems of linkage nor can they be definitely grouped, with the data in hand, among themselves. But the author says "Though the question we set out to answer cannot be regarded as finally settled, I have nevertheless come to the opinion that the number of linkage groups in Lathyrus will eventually be found to correspond to the haploid number of chromosomes"

The existence of linkage groups corresponding to the haploid number of chromosomes both in animals and plants is a strong evidence in favour of the location of hereditary units within the chromosomes, and Mandelian segregation can thus be made to correspond with the known cytological history of the organism.

But recent researches have shown that segregation is not confined to the reduction division. Definite evidences of somatic segregation are recorded by Bateson and Pellew[5] in Peas and by R. Gates[6] in Oenothera. The suppression of characters on crossing in wheat recorded by Biffen[7] may also be explained on the basis of somatic segregation. A similar case which is not yet thoroughly worked out is observed by the reviewer in Balsam (Impatiens) which produces flowers of different kinds on different branches in one and the same plant. Baur's explanation of Chimæras is well known, and Bateson[8] not only does not see any difference between the phenomena of segregation and inheritance observed in chimeras, root-cuttings and sports and cases of somatic segregation mentioned above, but also expresses the opinion, "It may well be that segregation is most commonly relegated to the divisions in the germ cycle, but I am unwilling to regard segregation postponed to the reduction division as a process distinct in kind from those somatic segregations of which bud sports are the visible manifestations." Gates[9], however, draws a distinction between somatic segregation, and

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[4] Ö. Winge.—"On the relation between number of chromosomes and number of types, in Lathyrus especially." Journ. Gen. Vol. VIII, No. 2, April 1919, p. 133.

[5] W. Bateson and C. Pellew.—'On the geneties of 'rogues' among Culinary Peas (Pisum sativum)". Journ. Gen. Vol. V, No. 1, July 1915, p. 13.

[6] R. Ruggles Gates.—"Vegetative segregation in hybrid race" *ibid.* Vol. VI, No. 3, April 1917 p. 237.

[7] R. H. Biffen.—"The suppression of characters on crossing." *Ibid.* Vol. V, No. 4, July 1916.

[8] W. Bateson.—"Root-cuttings, chimeras and 'sports'" *ibid.* Vol. VI No. 2, Dec. 1916, p. 75.

[9] R. Ruggles Gates.—*Ibid.*

meiotic phenomena which are believed to form the basis of Mendelian segregation" Punnett[10] describes a case of patching in the flower colour in Sweet Peas and while agreeing with Gates that this type of segregation is distinct in kind from the Reduction division and is independent of it, shows concurrence, as late as in December, 1922, with Bateson "that even in normal Mendelian heredity segregation may possibly be regarded as brought about on similar lines."

It is not easy to reconcile these views expressed in connection with somatic segregation and variegation with the chromosome hypothesis. Yet, if, as Bateson says, somatic segregation is not confined to a group of characters entirely different from those concerned in normal Mendelian inheritance, there seems to be no reason why segregation during the somatic phase should be extra-chromosomal or extra-nuclear while normal Mendelian segregation is chromosomal; and in view of the fact that the chromosome hypothesis is recieving greater support and wider acceptance as time passes, it would appear that recourse to new hypothesis is desirable only after all possibilities of reconciling cases of somatic segregation with the chromosome hypothesis are exausted. Whether somatic segregation, except in those cases where plastid—or cytoplasmic inheritance is definitely proved, is due to some aberration in the cytological behaviour in the somatic phase of the organism and, if so, whether, as might be expected, all units linked in the same chromosome are similarly affected, further work alone can decide.

R. S. INAMDAR.

[10] R. C. Punnett.—"On a case of patching in the flower-colour of the Sweet Pea (Lathyrus odoratus)." Journ. Gen. Vol. XII, No. 3, Dec. 1922, p. 255.

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ON THE MODE OF INFECTION AND PERENNATION OF THE SMUT OF "DOOB" (CYNODON DACTYLON PERS.)

BY

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Introduction

Magnus (4) has recorded as many as three different smuts on *Cynodon Dactylon* Pers, caused respectively by *Ustilago paraguariensis*, *U. Dregeana* and *U. cynodontis* P. Henn, which can be easily distinguished from one another.

Out of these three *U. cynodontis* P. Henn is the only one, as far as the author knows which occurs in the plains of India and does great damage to "doob" an important fodder grass in this country. The author has noticed the presence of smutted "doob" at many places in the United Provinces of Agra and Oudh, the Punjab, Central Provinces and Bihar, and keeping in mind the distribution of the host, it seems highly probable that the disease occurs also in other parts of India. In waste places and on lawns under cultivation one can easily find smutted specimens during the greater part of the year.

From his unpublished notes, I learn that S. K. Basu, assistant to the Imperial Mycologist at Pusa, carried on some inoculation experiments in the year 1906 with the object of finding out whether the host is infected in the seedling stage. Unfortunately he did not get any positive results. In the year 1916 I took up this piece of work at the suggestion of Dr. E. J. Butler, to whom I am very much indebted for casual advice and for the loan of literature from his library at Pusa.

The work was commenced at Agra and, during the period September 1916—August 1920, numerous inoculations on seedlings of

different ages and healthy flowers were made, but none of the experiments were successful. After my arrival in Cambridge, the work was continued at the Botany school, with air-dried material of diseased grass obtained from India by post. At last, in July 1921, after repeated trials, I succeeded in finding out the right stage for seedling infection. So far I have had no success with blossom infection of this host.

The author has attempted in this paper to give a fairly complete description of this species—*Ustilago cynodontis*. Out of a very large number of experiments, details only of the more important ones, have been recorded which indicate that it is only in the very young condition that the seedlings of doob are susceptible to infection by *U. cynodontis*. The present work also shows that the smut of doob furnishes another clear case of the perpetuation of a disease through a perennial mycelium hibernating in the underground parts of the host.

A short description of the parasite

The disease manifests itself in the region of the inflorescence as a black sooty mass emerging from between the enclosing leaves. As a general rule the whole of the young inflorescence is destroyed, and is replaced by a collection of powdery spores while still enclosed within the enveloping leaves and seldom yields any grain. Sometimes a few spikelets near the tips look quite healthy, but a microscopic examination of such parts reveals in most cases an active mycelium inside. In addition to the spikes, the main axis of the inflorescence within the enclosing leaves often becomes smutted over the whole surface, or at least the portion just below the panicle. In this smut, it is interesting to note that spore formation on the leaf blade and the stem is also quite common.

A transverse section through the smutted part of the main axis of the inflorescence shows, here and there on the periphery, sporiferous layers which have replaced the outer tissues of the host. At some places one finds a complete destruction of the epidermis, cortical parenchyma and even a part of the sclerenchymatous pericycle, at others it is only the epidermis and the outer layers of the cortex which suffer. In some parts however all the structures are quite intact, but under the higher powers of the microscope one finds a copious supply of the mycelium, both in the outer and the more deeply placed tissues and very often in the pith itself.

In the case of a plant bearing a diseased tip or an inflorescence, the roots, rhizome and the aerial branches, though looking quite healthy externally, show in suitable preparations fungal hyphae here

and there, particularly in portions of the ground tissue near the vascular bundles. The hyphae lie between the cells but are occasionally also intracellular. They are hyaline and measure 2·5–3μ in diameter with knob-like haustoria projecting into the neighbouring cells. Inside a cell of the host the hyphae are seen to be copiously branched and rather intricately fused with their ultimate tips frequently lobed.

The sori in the region of the inflorescence occur very often in a group of five more or less tangled threads, each representing a spike practically all the flowers of which have been replaced by spores. After brushing off the powdery spores one finds only the remnants of the glumes here and there and the short pedicels.

The spores are sub-globose measuring 7–8μ in diameter with a smooth margin and, as sketched by Magnus (4) with a distinctly reticulate epispore.

The spores retain their viability for a considerable length of time, as McAlpine (6) has already pointed out. The author collected some in November, 1916 and, in August, 1918, after a year and nine months, they still showed fairly good germination.

The germination of Spores

The author has tried several times the germination of fresh as well as old material in distilled water and also in a weak solution of an extract of horse dung but has failed to observe the formation of a 3 celled promycelium, as stated by McAlpine (6). In horse dung extract the spores show very good germination, producing a typically 4-celled promycelium, as observed by Brefeld (1).

The origin of two promycelia from a single spore does not take place very frequently. If allowed to remain on a slide in horse dung extract for a week or so the spores show a marked increase in the production of sporidia and in subsequent sprouting as the liquid in the solution dries up. It is interesting to note that sometimes the spores of this smut, when allowed to germinate in distilled water and even in horse dung extract, do not produce promycelia but develop more or less elongated germ tubes instead. This happens more frequently when there is plenty of liquid on the slide. Very often one sees both types of germination going on side by side. Blackman (9) has stated that the teleutospores of rusts also may not produce any sporidia or even the characteristic transverse walls of the promycelium if their germ tubes are submerged.

Brefeld (2) has quite definitely brought out an important fact concerning the connection between the mode of infection of the host

and the type of germination of the spores of the smut affecting it. He has stated that a smut which infects its host in the seedling stage shows a copious production of the germs of infection following the germination of spores in manured earth, and that such spores retain their viability for a very long time.

The facts that the smut of "doob" infects its host in the seedling stage and that the normal type of germination of spores in a nutrient solution yields a profuse formation of conidia, and also that the spores of this smut retain their viability for a long time are in complete agreement with Brefeld's observations.

Again McAlpine (6) has remarked that in cases of blossom infection of the host the spores produce no conidia at all. It is very difficult to say how far this fact suggests the possibility of a blossom infection as well being effective in this case. It is not impossible, but my inoculation experiments with healthy blossoms have so far given only negative results.

Seedling infection

Brefeld has done a considerable amount of work on cereal smuts and has obtained 30—40 per cent. infection in the case of Oats by covering the seed grain with infected compost and humus soil mixed with half its amount of horse dung.

He has concluded that in Oats, infection by smut takes place in the seedling stage immediately after germination. Similarly Butler (3) has remarked that in Oats the greatest number of successful inoculations is obtained just after the primary shoot has emerged from the grain and that after the shoot has reached a length of one inch infection is rare.

The following is a summary of experiments conducted by the writer on seedling infection of "doob" at different times from October, 1916 to July, 1919 with the object of finding out the length of the period for which the host remains susceptible to an attack by the smut.

1. Aerial parts of seedlings of different ages (from 21 days down to 7 days after sowing) were inoculated with moist spores and kept covered with bell jars or glass cases for 2—3 days. In two of the experiments the soil was also dusted with spores.

2. Some seeds were sown in saw-dust and seedlings about three weeks old were inoculated at the underground parts and then grown on Knop's solution for a week. The inoculated parts were kept above the surface of the liquid. The seedlings were transplanted into a pot after that.

3. Seeds mixed with moist spores or soaked together over night were sown in pots on four different occasions in October, February, July and August. Spores used for these experiments were either collected fresh or such as had been kept dry in the laboratory for a variable period (2 weeks—5 months). As already pointed out none of these experiments were successful although the germination of spores was always found to be quite satisfactory.

4. In view of the possibility of infection taking place only in very young stages some more inoculations were attempted in July, 1921. Seeds soaked previously over night were skinned on the 6th of July and allowed to germinate on moist filter paper in a covered petri dish. Young seedlings were inoculated with spores on the 11th of July and were transplanted into a pot on the 20th of the same month. The germination of spores was found to be very good. A control experiment was also arranged. It is interesting to note that no smutted inflorescence appeared in that pot.

5. Seeds soaked previously for 2 days were skinned and dusted with spores on the 21st of July and were allowed to germinate on moist filter paper in a covered petri dish. They were dusted again with spores on the 23rd (2 days later) when just sprouting. Seedlings were transplanted into a pot on the 28th. Out of 15 seedlings transplanted 4 did not germinate much further and died. Two young shoots were tested for mycelium in October following and one was found to be infected. One diseased inflorescence was observed on the 6th of January, 1922. After that five more smutted inflorescences were noted on four different plants.

The pots in the last two experiments were removed to the tropical pit at the Botanic gardens in October 1921.

These experiments show clearly that the aerial parts of seedlings even when they are tender are not susceptible to attack by the smut.

The underground parts too are not infected after some time as indicated by experiment (2).

It is difficult to account for negative results in experiments where seeds and spores were sown together. Walker and Jones (8) have shown that soil temperature is a factor of great importance with regard to infection of onion seedlings by smut (*Urocystis cepulae*).

It is quite possible therefore that temperature of the soil in those experiments was not favourable for a simultaneous germination of seeds of "doob" and the spores they were dusted with. It may be pointed out that the spores of this smut show fair germination even at 29—30°C.

Most probably the seedling remains susceptible for a very short time, certainly not more than three or four days from the time of the

sprouting of the seed. Otherwise there seems to be no reason why, in experiment No. 4, where the seedlings were inoculated on the 5th day after the soaked seeds were put on moist filter paper for germination, there should have been no infection. It may be pointed out here that in warm weather seeds which have been previously soaked sprout in 2—3 days.

In experiment No. 5 undoubtedly, conditions for infection were most favourable, since the seeds had been soaked for 2 days before being dusted with spores, to allow a simultaneous germination to take place so that by the time the seeds sprouted sporidia might be available.

Blossom infection

Among the cereals, the loose smuts of Wheat and Barley furnish clear examples of infection through the stigma. Brefeld (2) has remarked that blossom infection is the ruling form of infection, if not the only one, in the case of the loose smut of Wheat.

Having observed no diseased inflorescences on seedlings inoculated in October, 1916, the author attempted inoculation on healthy blossom of "doob" in April, 1917. One cannot be altogether sure of hitting at the time most favourable for infection of the stigma, but care was taken to inoculate flowers about the time when their pollen was being shed. Some healthy inflorescences showing ripe anthers in many of the flowers were removed with the main stalks and their cut ends dipped in a bottle containing distilled water. In some cases pot plants bearing healthy inflorescences were used. Spores were sprayed with an atomizer, or the spikes were dipped in a watch glass full of spores which had been allowed to germinate for two or three days in water, and the plants were kept covered for 2—3 days.

From April, 1917 to July, 1920 as many as seven trials were made with blossom infection. About two weeks after inoculation the inflorescences were dried and the seeds collected. Seeds from inoculated blossom were sown about four months after the date of collection and after disinfection with 2 per cent. Formalin. Seeds collected after the last experiment conducted in India in July, 1920 were sown on the 11th of May, 1921. As already stated above none of the inoculations with healthy blossom have been successful so far.

Brefeld (2) has remarked that we have to reckon in the case of most of the smuts with two places of infection *i.e.*, the young seedling and the blossom, and have therefore to consider the possibility of both these forms of infection being effective in individual cases. As regards the possibility also of blossom infection in the case of Oats, he has not come to any definite conclusions, but has expressed that

it is of lesser significance. Keeping in mind the marvellous success that has been achieved in checking the smut of Oats in different countries by the disinfection of the seed grain, one can safely say that Brefeld's observations are quite conclusive.

It is possible though very unlikely that blossom infection in the case of "doob" may be proved later on to be equally effective.

A perennial mycelium

The presence of fungal hyphae in the rhizome of a diseased plant of "doob" suggests to one the possibility of the perennation of this disease. In order to find out how far the mycelium inside the underground parts was effective in producing smutted blades and inflorescences year after year the following experiments were conducted.

1. Diseased "doob" (bearing smutted inflorescences) was transplanted in four tubs on the 10th of September, 1916. The tubs were kept in the open and observed occasionally. During a period of nearly four years only smutted inflorescences or shoots with smutted tops were noticed. The largest number of smutted shoots appeared during the summer rains. No healthy inflorescence was ever noted in them.

2. Diseased grass was transplanted in a tub on the same day as No. 1. The aerial parts were cut on November 20th and the tub was kept covered with a glass case for two weeks. Fresh shoots on examination invariably showed the mycelium inside. Only diseased inflorescences were noticed as in No. 1.

3. Healthy doob (inflorescences without any trace of smut) was transplanted in two pots on the same day. Only healthy inflorescences appeared in them.

4. Healthy grass transplanted like No. 3. The aerial parts were cut on November 20th and the pot kept covered for 2 weeks. Fresh shoots showed no mycelium.

5. Healthy grass transplanted in a pot showed two diseased inflorescences on November 25th. The plant bearing such inflorescences was dug out and on examination its rhizome as well as aerial shoots showed the mycelium inside. Other plants in the pot showed only healthy inflorescences.

The unexpected appearance of two smutted inflorescences in the last experiment was evidently due to the fact that a diseased rhizome bearing only young shoots (certainly without flowers) was somehow transplanted along with grass bearing healthy flowers.

From the observations recorded above it is clear that the perpetuation of this smut does not depend very much upon fresh

infection either of the seedlings or the blossom. Undoubtedly the mycelium in the underground parts is responsible for the perennation of the disease and its appearance in an epidemic form during the summer rains. a period so favourable for a luxuriant growth of the host. During the earlier part of summer (May and June), in the Punjab and United Provinces, one finds, on account of intense heat and drought only dried blades of this grass above the ground. The mycelium during such periods may well be said to be in a state of hibernation within the underground parts. Obviously young shoots arising from a diseased rhizome (Expt. 2.) are infected from the same source and ultimately end either in diseased inflorescences or in such shoots as show the formation of spores at their apices and terminal leaf blades.

It is unfortunate that cultivators use the underground parts rather than seeds of "doob" for the purpose of raising a lawn and that is the reason why one seldom sees a lawn altogether free from smut. An indiscriminate transplantation of diseased rhizomes, which are indistinguishable from the healthy ones except when in flower, is very undesirable.

It is possible however to avoid diseased rhizomes by making a careful selection at a time when the grass is in flower and by using only such stuff as has no diseased plants within a yard or two.

It seems likely that by the use of seed which has been disinfected the disease may to a considerable extent be checked.

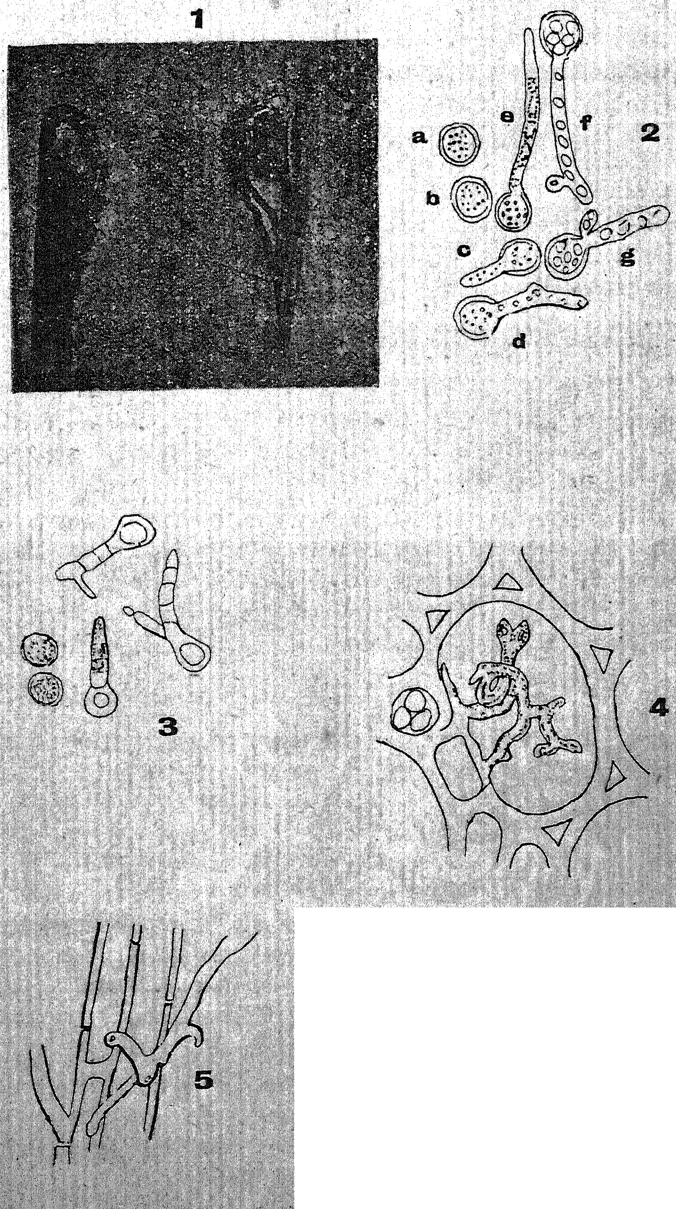
I wish to express my warmest thanks to Mr. F. T. Brooks, under whose supervision I worked at the Botany School, for some very useful suggestions in connection with this work. I am also very grateful to Mr. C. C. Calder, of the Botanical Survey of India, for a very reliable collection of healthy seeds that he sent to me on request.

Summary

The smut of "doob" caused by *Ustilago cynodontis* P. Henn is of very common occurrence on the plains of India. Besides destroying the whole of the inflorescence which seldom yields any grain the smut frequently makes its appearance at the apices of short aerial shoots and their terminal leaf blades. The latter fact makes this disease far more serious because "doob" is an important fodder grass in this country.

The host is infected in the earlier stages of germination of the seed and ceases to be susceptible very probably within three or four days after its sprouting. So far blossom infection has not been found to be effective.

THE SMUT OF "DOOB" (CYNODON DACTYLON PERS.)



Ustilago cynodontis P. HENN, or the Smut of "Doob".

The perpetuation of this disease is brought about also by a perennial mycelium which hibernates in the rhizome beneath the surface.

The use of rhizomes in cultivation is therefore responsible to a great extent for the spread of this disease, and should be discouraged.

DEPARTMENT OF BOTANY,
AGRA COLLEGE, AGRA,
April, 1923.

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Explanation of Plate

Fig. 1. A photograph showing two smutted inflorescences, × 3.

Fig. 2. Spores of *Ustilago cynodontis* and their germination without the formation of promycelia.

(*a*) and (*b*) spores, (*c*), (*d*) and (*e*) germination of spores after 48 hours, (*f*) and (*g*) germination of spores after 72 hours × 1000.

Fig. 3. Spores showing normal type of germination and promycelia × 750.

Fig. 4. Transverse section of a diseased shoot showing intracellular hyphae × 1000.

Fig. 5. Longitudinal section of a diseased shoot showing hyphae and haustoria × 1000.

PROCEEDINGS OF THE SECOND ANNUAL MEETING OF THE INDIAN BOTANICAL SOCIETY

The 2nd Annual Meeting of the Indian Botanical Society was held at Lucknow, in January, 1923. In the absence of the President of the Society, M.R.Ry. Rao Bahadur K. Rangachariar, Avl., M.A., L.T., Dr. S. P. Agharkar, M.A., Ph.D., F.L.S., Vice-President of the Society presided and delivered the presidential address.

PRESIDENTIAL ADDRESS

The Present Position of Our Knowledge of the Aquatic Flora of India

When I was elected Vice-President of the Indian Botanical Society for the year 1922, I hardly expected that I would have to address you on the occasion of its Annual Meeting. Circumstances over which he had no control have prevented our President Rao Bahadur Prof. K. Rangachariar from taking the chair on this occasion and delivering the customary address. I, therefore, had to take upon myself that duty, knowing fully that I would not be able to do adequate justice to it.

The subject that I have chosen for to-day's address is "the present position of our knowledge of the Aquatic Flora of India." It must be confessed at the outset that our knowledge of this branch of Indian Botany is mainly based on systematic works and Floras. No connected account of the Aquatic Flora of India as a whole or any part of it has yet been published. Such a work would need for its adequate performance the joint labours of a number of workers. The number of Indian Botanists, apart from officers of the various government departments, being small it is no wonder that such a work has not yet been undertaken. It is, however, encouraging to see that the number of workers in our Universities and Colleges is steadily increasing and that some of them have already contributed towards an increase of our knowledge of the Aquatic Flora. This is not at all surprising looking to the places where our Universities and Colleges are situated. Some of them like Bombay and Madras are situated on the sea, others, like Calcutta, Benares, Allahabad and Lahore, on the banks of rivers with a rich aquatic flora. In the immediate vicinity

of several of thsee again are numerous pools, ponds and lakes with a rich aquatic vegetation. All the conditions which would create an interest in this branch of Botany being thus present, it is not unnatural to expect that larger numbers of workers will be forthcoming and we shall be able to fill up the gaps in our knowledge at no distant date.

With these preliminary remarks I pass on to consider the state of our knowledge of the different groups of the vegetable kingdom. We shall thus be better able to get a clearer view of these than otherwise.

Starting with Algae as the group of aquatic plants *par excellence* we have at first to notice the absence of any general work on the Algæ of India or any part of it. Nearly all the papers that have been published on Indian Algæ have been based on material collected casually by Government Officials; and in some cases material has been got together by scrapings from herbarium sheets of Phanerogams. It is, therefore, quite evident that our knowledge of Algæ is very scrappy and a great deal remains to be done before a work on "Indian Algæ" can even be attempted.

As information about Algæ is scattered in a number of places it seems to me to be worth while to give a short résumé of the various papers extant. The earliest mention of Indian Algæ is contained in *Royle's* Botany of the Himalaya Mountains, etc., (1839), where he refers to "Nostochinæ", "Confervæ" and "Lemanias" occurring in the mountain streams of the Himalayas. The next paper is by *W. Griffith* "on the Cryptogamic plants of Dr. Roxburgh" forming the 4th Volume of his "Flora Indica". *Alexander Braun's* "Characeæ Indiae orientalis et insularum maris pacifici" or "characters and observations on the Characeæ of the East Indian continent, Sunda Islands, Marians and Sandwitch Islands" published in 1849 is perpaps the first important contribution to the study of Indian Algæ. Written by the greatest authority on the Characeæ it forms a sure foundation on which to base all future work on the group. The number of species described was only eleven for the vast area, which was due to the small collections the author had for examination.

A paper by *G. S. Wallich* on Desmids from a district of Lower Bengal published in the Annals and Mag. of Nat. History (1860) is the next important contribution to the study of Indian Algæ. *Dr. G. von Martens* has a paper "on Burmese Algæ" in J. A. S. B. XL (1872) dealing principally with Desmids.

G. Zeller in his paper on Algæ collected by S. Kurz in Araccan and British Burma (J. A. S. B. XLII pp. 11, (1873) describes 155

Algæ of all families, including 4 Charophyta by A. Braun. This was followed by a paper by *Leuduger Fortmorel* entitled Catalogue des Diatomee's de l'ile de Ceylon (1879 St. Brieve) describing a number of Ceylon Diatoms. *Dickie's* paper "Notes on the Algæ of the Himalayas" (1882) based on Collections by Dr. Watt in the upper Batong valley of Sikkim, between 13,000'—18,000' is perhaps the only paper dealing with Algæ from the high mountains. The paper includes descriptions of four species each of Vaucheria, Conferva, Œdogonium, Zygnema and Scytonema together with 13 species of Desmidiaecæ and 28 species of Diatoms.

In 1886 *Joshua* (William) published (J. L. S.) descriptions of Burmese Desmidiaceæ, including some new species. This paper describes 186 species and varieties belonging to 16 genera which were collected from dried leaves of Pistia stratiotes. In the same year *Scharenschmidt* published Notes on "Afghanisthan Algæ" based on specimens chiefly found adhering to dried Phanerogamic plants collected by Aitchison in the Afghanisthan expedition in 1880. This paper contains a description of 60 species belonging to various families. Both these papers show how by a careful examination of even the most unpromising material valuable contribution to the knowledge of the Algal flora of inaccessible regions could be made.

In 1888 *Lagerheim* published a paper "Über Desmidiaceen aus Bengalen" in Bihang, K. Svensk. Vet. Akad. XIII.

The next important contribution to the Algal flora of India is by *Turner* (W) who published in 1892 a richly illustrated paper "On the freshwater Algæ, principally Desmidiaceæ from East India" based on Wallich's material chiefly collected from the Raneeganj area. This paper contains descriptions of a large number of Desmidiaceae and other Algæ. The total number of species described in this paper is over 700. Messrs. *W. and G. S. West* published in 1902 a paper in the Trans. Linn. Soc. Bot., "A contribution to the freshwater Algæ of Ceylon", based on collections by Freemans in various parts of Ceylon, describing over 400 species of various families. The same authors contributed in 1907 a paper to the Annals R. B. G. Calcutta. "On the freshwater Algæ from Burma including a few from Bengal (Burdwan) and Madras." This was based on the collections made by Burkill and contains a description of 300 species belonging to 71 genera of Freshwater forms. One result of this study has been to demonstrate the existence of "a most characteristic Desmid-flora of the Indo-malayan Area."

The next paper on Indian Algæ is by Svedelius "on Ecological and Systematic studies of the Ceylon species of Caulerpa" (1906)

forming No. 1 of the Reports on the marine Algæ of Ceylon. So far as I am aware no papers on Indian Algæ have been published between 1906—1919. In that year three papers were read before the Botany Section of the Indian Science Congress of which two by *S. L. Ghose* dealt with the Algæ of the Punjab and one by *Professor M. O. Parthasarathy Iyengar* dealt with the Madras Algæ. None of these papers have yet been published in extenso.

The brothers *Henry and James Groves* have been chiefly instrumental in increasing our knowledge of Indian Characeae. James Groves published in 1922 a paper on Ceylon Charophyta (Journ. Linn, Soc.) describing among others 2 new species of Nitella. The total number of species now known of this group is 38 according to a manuscript list by J. Groves.

In the same year *P. Brühl and K. Biswas* published a paper "On the Algæ of Bengal Filter Beds"—including descriptions of some new species. (Journal Coll. of Sc. Cal. U.)

Reviewing the literature on Indian Algæ as a whole we notice that nearly the whole of it is based on rather scanty material. Almost the only group which is fairly well known is the Desmidiaceæ of which over 700 species are known. The Characeæ with 38 known species is the next best-studied group. Of Marine Algae the best known group is the Caulerpas, although a few species of most other groups have been mentioned by various authors.

Another point worth mentioning is that the Algæ described up to now have been collected in a few places only. No collections from vast areas of the country have been made outside Bengal, Burma and Ceylon. It is here that younger men have the greatest opportunity of increasing our knowledge. When collections will be made from all parts of the country and described, we can proceed to the study of problems concerning their distribution and origin.

Fungi

Very little is known about aquatic Fungi from India or the neighbouring countries. This is principally due to the small number of mycologiots in India and their being occupied with problems connected with Agriculture. Up to now only one aquatic fungus has been described from India by *Butler* (Allomyces) (Ann. Bot. XXV, 1911). There is thus a vast field open to younger workers. some of whom being connected with Universities are free to choose their own line of study. I might particularly draw the attention of workers to the Laboulbeniaceae which are parasitic on living aquatic or riparian insects and of which numbers will surely be found

if properly searched for. Up to now there is no record of any Laboulbeniaceae from India, although there is no reason why they should not occur.

Hepaticae

Very little is known regarding the aquatic Liverworts of India. In fact our knowledge of Indian Liverworts in general is not very great. Excepting *Mitten's* paper on "Hepaticæ Indiæ Orientalis" published so long ago as 1861, there is hardly a paper dealing with this class in general. *Kashyap* has in the last few years contributed materially to our knowledge of the Himalayan Liverworts and, their distribution but a work dealing with the Indian Hepaticeaæ in general is still a desideratum.

Musci

What has been said above about Liverworts applies with equal force to the Mosses. *Mitten's* "Musci Indiæ Orientalis" published in 1859 still remains our main source of information. *Brotherus* published in Rec. Bot. Surv. Ind., (1899), "Contributions to the Bryological flora of Southern India." "*H. N. Dixon* has described in Vol VI of the same periodical (1914), "The mosses of the Abor Expedition" and "The Mosses collected by C. E. C. Fischer and others from India and Ceylon." The same author has published in the Journ. Bomb. Nat. Hist. Soc. notices of Mosses collected by L. J. Sedgwick from parts of the Bombay Presidency. A certain amount of information about Indian Mosses is contained in *Fleischer's* Moss Flora of Buitenzorg which is in the course of publication.

Pteridophyta

Our knowledge of the Pteridophyta is much more complete than that of the Bryophyta, for which reason the aquatic forms are also much better known. *The Hydropterideae* are represented by several species belonging to both the Marsiliaceæ and Salviniaceæ, and the *Isoetaceæ* are represented by I. coromandelina occuring in various parts of India. Apart from these the *Polypodiaceous* Ceratopteris thalictroides is known to occur in standing water in various parts of India. The *Equisetaceæ* are represented by several species one of which E. debile has been thoroughly studied by *Kashyap*.

Phanerogams

Our knowledge of the Taxonomy of aquatic Phanerogams is fairly complete through the publication of Hooker's Flora of British India, as well as the various local Floras supplementing it. Excepting the Podostemaceae of which a number of new species will be found, only a small number of novelties are likely to be discovered. The Ceylon

Podostemaceae have been thoroughly investigated by Willis, but owing to the very restricted distribution of species of this group new forms are still to be expected in different parts of India.

Our knowledge of the biology and oecology of the aquatic Phanerogams is still very fragmentary and of comparatively recent date. Apart from "Notes" in Griffith's Notulæ, a number of papers has been published during the last twenty years showing that the subject is engaging the attention of a number of workers. The list of papers however also shows that our knowledge is still very incomplete and much work has still to be done. Let us hope that the interest exhibited by our younger workers in this branch will increase and we will have, at no distant date a fairly comprehensive general treatise dealing with our aquatic flowering plants. I might also draw the attention of workers to the great necessity of a thorough biological study of an aquatic pest aptly named "The Lilac Devil" which is progressively blocking up the waterways of Bengal and other parts of the country, thus constituting a great menace to the economic life of our country. This question has a great economic importance, but it can only be rationally dealt with by studying the plant in all its aspects.

Reviewing the present position of our knowledge of the Aquatic Flora of India as a whole, we find that some groups are better known than others. Even when a group is well known from one part of the country it is not so well known from other parts. This being the case the immediate problems that offer themselves for study are also different. In the less known groups like Algae, Fungi, Liverworts and Mosses more taxonomic work is needed, whereas in the better-known groups work on the biology, oecology, distribution and origin can be more profitably undertaken. I am, however, not without hope. The Indian Universities are now taking an increasingly larger share in the aquisition of knowledge than they used to do and the facilities in the country for study and research are being augmented, resulting in greater output. The very fact that our society, only 2 years old, has a membership of nearly 170 and that we have at this meeting decided to undertake the publication of our own journal, are very encouraging signs. The old times when all research work was done by the staffs of the scientific departments of the Government of India are slowly passing away and I hope the time will not be far distant when no appointment on the staff of a University will be made without research qualifications. Let us hope therefore that our knowledge of the Aquatic Flora of India will be increased very materially at no distant date.

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ABSTRACTS OF PAPERS READ

Succession of epiphytes in the *Quercus incana* forest at Landour, Western Himalayas.—*By* WINFIELD DUDGEON, *Ewing Christian College, Allahabad.*

Landour is situated in the outer Western Himalayas, 78° 6′ E. Long., and 30° 27′ N. Lat., 7,000 ft. above sea level, in the range of the climatic climax *Quercus incana* forest. Rainfall is about 250 cm. The climate is dry and sunny during spring, mild with heavy rains (85 per cent. of the total precipitation falls between June and September) and high humidity during the summer monsoon (when the epiphytes make practically all of their growth), dry and sunny during autumn, and cool with considerable snow in winter.

This is a study of the succession of the epiphytes on the trees of the *Quercus incana* forest. Six stages of this miniature topographic succession may be distinguished :

(i) Crustose lichen stage, beginning when branches are three or four years old.

(ii) Foliose and fruticose lichen stage, with *Usnea* and other forms reaching considerable profusion and luxuriance.

(iii) Pioneer moss stage, when mosses begin to appear along with the lichens and gradually displace them as the dominant vegetation.

(iv) Climax moss stage, where *Leucodon secundus*, *Cryptoleptodon flexuosus*, and *Diaphanodon blandus* form a dense continuous mat of vegetation about the branches. Under good conditions it is attained in about 20 years, and persists till shaded out by the next stage. A bed of soil begins to accumulate in the moss pad.

(v) Fern stage, with *Pleopeltis simplex*, *Leucostegia pseudocystopteris*, and *Goniophlebium lachnopus* appearing in the order named. Mosses and fern stems and roots accumulate and hold more soil, and in the shade of the ferns a series of small epiphytic soil mosses make their appearance.

(vi) Flowering plant stage, dominated by *Tripogon filiformis*, *Thalictrum saniculaeforme*, *Sedum trifidum* and *Begonia amoena*. This stage persists almost indefinitely. Occasionally large patches of bark and accompanying vegetation drop off and the denuded areas are then revegetated by secondary successions of mosses.

Identification of the species is incomplete. About 45 spp. of lichens, 10 of liverworts, 50 of mosses, 4 of ferns, and 12 of flowering plants have been found taking part in the various stages of the succession.

Details of composition of the various stages, and rate of succession depend on (1) exposure to wind, (2) bark characters of the tree, (3) direction of growth of the branches, and (4) dissemination of the species involved.

The succession shown by epiphytes is considered to be unique, because of (1) the short time required for completion, (2) the unusual clearness of the successive stages, (3) the small size of the plants involved, and (4) the adaptation of the plants to repeated and prolonged dessication. It is possible that further study of the succession of epiphytes may throw new light on the problem of succession of terrestrial plants.

Note on the strand, mangrove and halophytic vegetation found near the mouth of the River Cooum at Madras.—*By* M. O. Parthasarathy Iyengar, *Presidency College, Madras.*

The author gave an account of the mangrove, strand and halophytic vegetation which was found near the mouth of the river Cooum, at Madras. The strand vegetation consisted principally of *Thespesia populnea*, *Cerbera odollam*, *Pongamia glabra*, *Erythrina indica*, etc. The mangrove vegetation was represented solely by *Avi-*

cennia officinalis. And the halophytic vegetation consisted of *Suæda nudiflora. Sesuvium portulaccastrum* and *Heliotropium curassavicum.*

Since the annual floods keep changing the nature of the soil every year, no permanent types of vegetation have been formed except in a few places which have been occupied by the members of the strand formation. And with each change in the nature of the soil caused by the floods every year, there is a corresponding change in the nature of the vegetation,—brought about by the dying out of the previous forms and the coming in of the new forms adapted to the new soil conditions.

On the adaptation of some perennial plants from the Lucknow flora to the marked periodicity of the climate.— *By* S. K. MUKERJI AND T. C. N. SINGH, *Lucknow University.*

Preliminary results of an ecological investigation of some representatives of the Dry Meadow Stage.

(i) Biology of the hot season perennials.

(ii) Ecological anatomy and protective devices.

(iii) Nature and utilization of the reserve food materials.

(iv) Determination of climatic and edaphic factors with the aid of instruments.

Plant successions of the Satpura Range (near Pachmarhi).—*By* S. K. MUKERJI, *Lucknow University.*

An account of the principal plant associations met with in passing from the open flat country near Piparia to the top of the Pachmarhi plateau.

A description is also given of the plant successions leading up to the Climatic Climax.

Ecological studies of the vegetation of the Vindhyas.— *By* S. K. MUKERJI, *Lucknow University.*

This paper embodies the result of an investigation, extending over two summers, of the principal plant associations of the Vindhyas (in the vicinity of Jubbulpore).

The author applied Raunkiaer's Statistical Methods including his "Life-forms" and "Leaf size classes" to the study of the vegetation.

The concluding part deals with the plant successions.

Bates evaporimeter records for Allahabad for the past year.—*By* D. N. COONDOO, *Ewing Christian College, Allahabad.*

A contribution to our knowledge of the anatomy of *Equisetum debile*.—*By* H. P. CHOWDHURY, *Lucknow University.*

The paper deals with the distribution of the endodermis in the different parts of the axis, the stucture of the nodes and inter-nodes, and the transition from the embryonic stem to the primary root.

On *Tmesipteris Vieillardi* Dangeard, an erect terrestrial species from New Caledonia.—*By* B. SAHNI, *Lucknow University.*

The aberrant genus *Tmesipteris* is known under several more or less distinct forms, which Dangeard described as so many separate species, but which are now generally included under Bernhardi's original species *Tm. tannensis.* The form *Vieillardi* of Dangeard, hitherto known only from herbarium specimens, differs from all the others in its rigidly erect terrestrial habit and especially in the presence of one or more medullary xylem strands which are strictly cauline and usually end blindly in the pith. These are regarded by the author as primitive features, sufficient to justify the recognition of *Tm. Vieillardi* as a substantive species, from which the pendulous epiphytic forms may have arisen. The presence of medullary xylem in the stem of one of the Psilotaceæ facilitates a comparison with the Devonian genus *Asteroxylon* and with *Lycopodium.*

The author records the presence of internal phloem not only in *Tm. Vieillardi* but also in other forms of the genus.

The concluding part deals with theoretical questions. The Psilotaceæ are regarded as the sole survivors of a race of primitively rootless plants.

Rusts of Wheat: a Physiological Study.—*By* KARM CHAND MEHTA, *Agra Colllege.*

While attempting to investigate the causes of the annual recurrence of rusts on cereals in the vicinity of Cambridge, the writer carried on extensive culture work on all the three rusts parasitic on wheat, side by side, for a period of nearly two years. The cultivation of these rusts accompanied by frequent field observations and experimental work directed to study the influence of external factors (specially

temperature) on their mycelium and uredospores has suggested an adequate explanation of their recurrence and also of the sequence of their appearance in nature. There are striking physiological differences between the rusts under report when subjected to the same treatment as shown by a study of the length of the incubation period and the influence of temperature on the viability of the uredospores.

A note on the life-history of *Uromyces Aloes* **P. Magn.**—*By* S. L. AJREKAR AND B. R. TONAPY. *College of Agriculture, Poona.*

1. The life history of *Uromyces Aloes* (Cke) P. Magn. (which was found on leaves of *Aloe vera* at Talegaon, Poona District) has been worked out by the authors and is seen to include only two spore forms, Teleuto- and Spermatia. Infection with sporidia from the teleuto-spores produces a mycelium which first gives rise to spermogonia and then to teleuto-sori. The spermogonia have not been noticed by previous observers.

2. The germination of the teleuto-spores is peculiar in that the promycelium is usually divided into two (rarely three) instead of the typical four cells and the apical cell functions directly like a sporidium putting out a thread like germ tube.

Artificial culture of *Psathyra lucipeta* **B. and Br**—*By* S. R. BOSE, *Carmichael Medical College, Calcutta.*

Specimens of *Psathyra lucipeta* B, and Br. (Subfamily Melanosporæ, Agaricaceæ) were collected from a moist log in Cornwallis Square Tank, 16th June, 1922. The stalk is central, white, hollow, and about 4.6 cm. long; the cap is brown, umbrella-shaped, slightly umbonate, and about 2 cm. in diameter; the gills are adnate, brown, narrow, and crowded; and the spores are brown and oval, 8×6 microns. A culture was made from the wood containing the mycelium of the fungus within its tissues. A piece of the wood was sterilised on the surface by adding a few drops of alcohol then holding it against the flame of a Bunsen burner for a few seconds, and was kept in a slanting sterile tube with a little water at the bottom. In the course of four days a fine cottony growth of mycelium was visible on the outside, on the sixth day a small brownish button with a white stalk appeared, and on the tenth day full growth was reached. After two or three days, when the first specimen had shrivelled up, another growth was observed on the same wood. Room temperature varied from 84° to 88° F, and moisture from 76° to 80°.

Edible Mushrooms of Bengal and their artificial culture.—*By* S. R. BOSE, *Carmichael Medical College, Calcutta.*

The edible mushroom *Collybia albuminosa* (Berk.) Petch is always reported to be found in connection with ant-hills, growing direct from the combs. This story is repeated in accounts of fungi in ant-nests in India, Ceylon, Malaysia, South America, Africa and Madagascar. Earlier Indian records were from places outside Bengal. Now, it is interesting to trace the same history of development in Bengal, Chilka Lake (Madras), and Holkar State. Many investigators have attempted to make artificial cultures of *Collybia albuminosa*, but have been unsuccessful.

The tissue culture method has been successful recently with another Bengal edible mushroom, *Volvaria terastius* B. and Br., common on heaps of decaying straw. Details of the method are the same as recently published for *Panaeolus cyanascens* B. and Br. (Sir Ashutosh Mukherjee Silver Jubilee Volumes, Calcutta Univ., Sci. Ser., Vol. II. pp. 81-84).

***Hydrodictyon indicum*, a new species from Madras.**—*By* M. O. PARTHASARATHY IYENGAR, *Presidency College, Madras.*

The author described a new species of *Hydrodictyon* which was collected by him at Madras last year. The cœnocytes were very thick and long—about 1 m.m. thick and 10 m.m.—16 m.m. long. The cell wall was very thick and had on the inside numerous curious knob-like thickenings projecting from it into the protoplasm which formed a thin layer lining the cell wall leaving a big vacuole in the middle of the cœnocyte. The nets were, like those *Hydrodictyon africanum* Yamanouchi, very brittle and easily broke up into the individual cœnocytes on being handled.

A contribution to the study of Indian Zoocecidia.—*By* A. H. SUNDAR RAMAN, *Calcutta University.*

All the available information about Indian zoocecidia has been brought together, and some galls are recorded for the first time. A bibliography is appended.

A critical note on *Crotalarta madurensis* Wight and *C. candicans* Wt. and Arn.—*By* P. M. DEBBARMAN, *Royal Botanic Garden, Calcutta.*

The writer is doubtful about the separability of these two supposed species, which are found to be connected by several intermediate

forms, and are hardly distinguishable in the field. Following Baker, Cooke, and Fyson, he is inclined to regard *C. candicans* as only a form of *C. madurensis*. Opinions of South Indian botanists are invited.

A peculiar bulb of ***Allium sativum*** **L.**—*By* P. M. DEBBARMAN.

A compound bulb consisting of a large primary bulb and a small supernumerary bulb seated on the apex of a structure analogous to the scape is described. The supernumerary bulb probably represents an abortive inflorescence in which the flowers have been replaced by bulblets, which are quite well suited for vegetative propagation, the sexual mode of reproduction having had no opportunity to come into play.

An instance of staminody and multiplication of petals in ***Cadaba trifoliata*** **W. and A.**—*By* P. M. DEBBARMAN.

The writer describes a flower of *Cadaba trifoliata* in which, instead the of two petals ordinarily met with, there are three petals and a stamen in place of a missing fourth petal, and the limb of the disk is three-lobed.

On the Protandry of the flowers of ***Aeschynanthus Hookeri*** **Clarke.**—*By* M. O. TIRUNARAYANA IYENGAR, *Department of Public Health, Bengal (Calcutta).*

The author describes an interesting kind of protandry which he observed in *Aeschynanthus Hookeri* Clarke which is commonly growing on trees in the Darjeeling district. The pistil at the time of the opening of the flower is very small and grows gradually to nearly six times its original length in the course of 5—7 days when the stigma also matures. At this stage the stamens which were projecting forward from the mouth of the corolla curl away from its anterior position as in *Clerodendron*.

The effect of Co_2 Concentration on the intake of Co_2 by leaves during assimilation.—*By* R. S. INAMDAR, *Benares Hindu University.*

It is noticed that as the concentration of Co_2 approaches the limiting value the intake does not take a sharp turn at the corner as is to be expected on the basis of Limiting factor idea but it forms a curve gradually rounding off at the corner. The cause for this deviation from the typical "Limiting factor curve" is under investigation.

A NOTE ON THE LIFE HISTORY OF *UROMYCES ALÖES* (CKE) P. Magn.

BY S. L. AJREKAR, B.A.,

Plant Pathologist to the Government of Bombay, Agricultural College, Poona,

AND B. R. TONAPY,

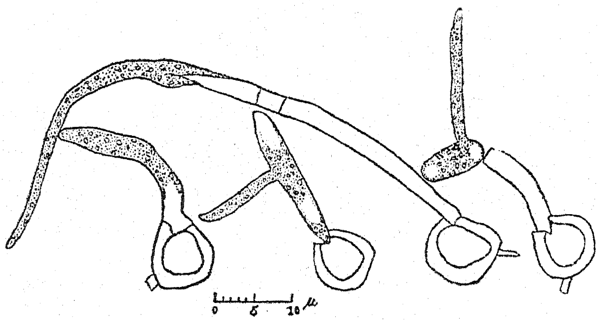
Assistant in the Section of Plant Pathology, Department of Agriculture, Bombay.

A species of *Uromyces* was collected in August, 1921 at Talegaon (Dhamdhere), District Poona, on leaves of *Aloe vera*. It produces on all surfaces of the thick leaves, large, elliptical spots which have a dull yellow ground colour, relieved by the grey or dark brown of the numerous teleuto-sori which are arranged in concentric circles. The spots vary considerably in size and frequently run together thus losing the typical elliptical form and occasionally covering the greater part of the leaf in extreme cases. In addition to the grey, still unopened and the dark-brown, burst teleuto-sori, close inspection may reveal in some of the spots little orange-coloured or black dots, also disposed in concentric rings, usually towards the centre of the spot and surrounded by one or more rings of teleuto-sori. (Fig. 1). These seem to have escaped the notice of previous collectors of this fungus on other species of *Alce* and are the mouths of underlying spermogonia.

The fungus was examined in the laboratory of the Imperial Mycologist, Pusa, and identified with *Uromyces Alöes* (Cke) P. Magn. From information received from the authority just mentioned, this fungus was originally collected on various species of *Aloe* in East Africa. (*e.g.* A. Baumii, A. maculatae, and A. saponariae, etc.). The list of specimens in the Mycological Herbarium of the Agricultural Research Institute, Pusa, includes this fungus occurring on Aloe spicata and collected at Coimbatore and it was after comparison with this specimen that the fungus on *Aloe vera* was identified with it.

The teleuto-spores were found to germinate immediately in distilled water without undergoing a period of rest. This takes place by the putting out of a thick germ tube (promycelium) into which the granular contents of the spore travel. These are pressed into the apical portion of the tube which then becomes cut

off from the basal empty part by a septum. Sometimes a second septum is formed in the granular portion, the germ tube thus being divided into three cells instead of the usual two. More than two septa have rarely been observed. The apical cell (or cells) which is



GERMINATING TELEUTOSPORES OF *Uromyces Alöes* (cke) P. Magn.

full of granular protoplasm soon afterwards puts out from the tip or side a thread-like-hypha which grows out to a considerable length and the-granular contents pass into it leaving the parent cell empty. Unlike in the typical teleuto-spore germination, no sporidia are borne on these threads which themselves behave like the germ tubes from sporidia in other rusts. The promycelial cells with their thread-like out-growths are sooner or later separated from the empty part of the promycelium and function actually as sporidia. This peculiarity of germination recalls that of the genus *Barclayella* Diet. and is believed to belong to primitive types of rusts.[1]

The germinating spores, when placed on the surface of the leaves of *Aloe vera* in drops of water and kept under a belljar, easily give successful infection. Yellowish oval spots of the size of a millimetre or two in length begin to make their appearance in about a week after the sporidia are placed on the leaves and indicate the success of the infection. These spots, on closer observation, reveal the presence of small orange-coloured dots which under the microscope are seen to be spermogonia, which are typically spherical and occasionally oval, with a slightly projecting neck, and situated just under the epidermis. (Fig. 2) These measure 14·5—17·5μ in diameter. They produce inside them minute spermatia in the usual manner. The spots rapidly increase in size and little raised yellow pustules averaging in size about

[1] McAlpine D.—The Rusts of Australia, p. 33.

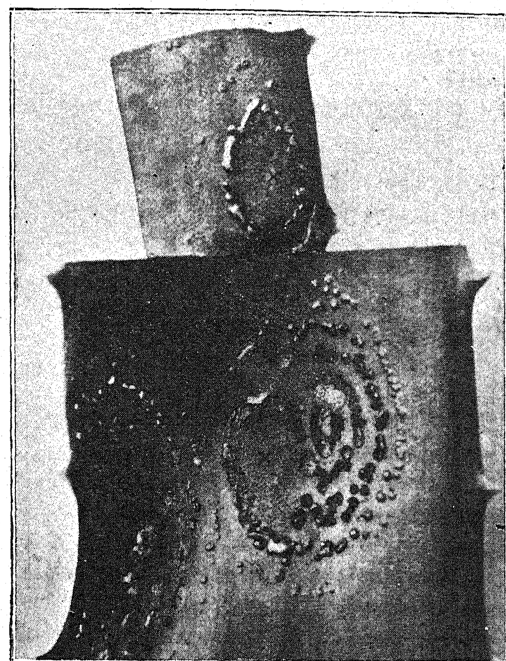


FIG. 1.

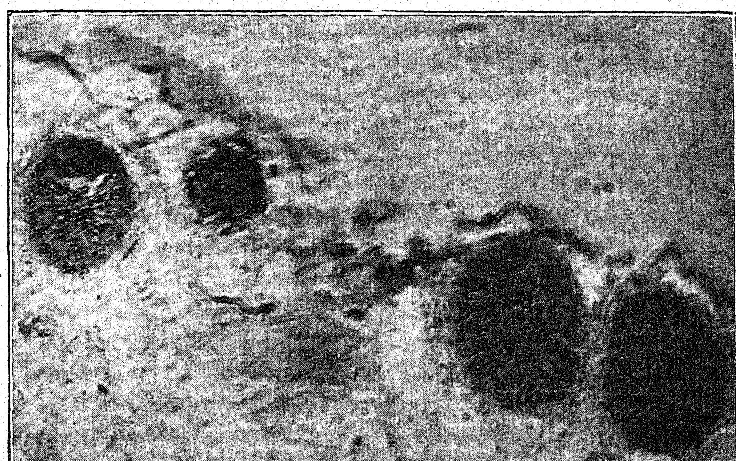


FIG. 2.

Uromyces Alöes (Cke) P. Magn. on leaf of *Aloe vera*.

Fig. 1. Teleuto pustules and Spermogonia (marked X) on leaf of Aloe vera.

Fig. 2. Spermogonia in section (micro-photograph).

½ to 1 mm. appear on them in rings one after another, beginning from the centre, so that the outer rings are successively younger than the inner ones. The pustules turn from yellow to grey as the teleuto-spores mature below the epidermis until finally they burst and liberate a dark brown powder consisting of the mature spores.

Fresh infections may occur any time during the cold and rainy seasons, but the fungus appears to remain dormant during the hot weather. No fresh infection was noticed on the plants under our observation during the months of April and May, 1922, the spots having dried up owing to the hot weather, (maximum 107. 0 F—Minimum 58· 4 F). Fresh spots began to appear on these same plants, however, when rainy weather set in, due to the resumption of activity by the fungus in moist weather.

The life history of *Uromyces Alöes* is thus very simple. It has only one functional spore-form, the teleuto-spore, which continually reproduces itself. Spermatia (pycnospores) are produced but take no known part in the perpetuation of the fungus. The life history of this fungus in thus in complete accordance with Arthur's[1] generalisation that " telia (teleuto-sori) associated with pycnia (spermogonia) may be safely assumed to belong to a genus in which aecia (aecidial stage) and uredinia (uredosori) are wanting, or at most so little developed as to be of no taxonomic importance. '

30th November, 1922.

Summary

1. The life history of *Uromyces Aloes* (Cke) P. Magn. has been worked out and is seen to include only two spore forms, Teleuto- and Spermatia. Infection with sporidia from the teleuto-spores produces a mycelium which first gives rise to spermogonia and then to teleuto-sori. The spermogonia have not been noticed by previous observers.

2. The germination of the teleuto-spores is peculiar in that the promycelium is usually divided into two (rarely three) instead of the typical four cells and the apical cell functions directly like a sporidium putting out a thread like germ tube.

DEPARTMENT OF BOTANY,
UNIVERSITY OF ALLAHABAD.

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1 Arthur J. C.—Journ. of Mycology, September, 1906.

SUCCESSION OF EPIPHYTES IN THE *QUERCUS INCANA* FOREST AT LANDOUR, WESTERN HIMALAYAS. PRELIMINARY NOTE.

By Winfield Dudgeon,
Ewing Christian College, Allahabad.

Landour is situated in the outer Western Himalayas, 78° 6′ E. Long., and 30° 27′ N. Lat., at an altitude of 1900–2200 m., in the midst of the *Quercus incana* climatic climax forest. The climate is decidedly periodic, due to the combined effects of: latitude, producing a distinct alternation of winter and summer; altitude, making Landour about 10° C. colder than the nearby Plains; and nearness to the Plains, resulting in an alternation of wet and dry seasons characteristic of a monsoon climate. Spring is dry and sunny; June to September is mild or cool, with heavy rains (about 85 per cent. of the total 250 cm. precipitation falls during this period) and high relative humidity; autumn is dry and sunny; and winter is cool with considerable snow. Epiphytes make practically all of their growth during the summer monsoon.

This study, made during the summers of 1921 and 1922, is concerned with the "topographic" succession of the epiphytes on the trees of the *Quercus incana* forest, mainly on *Quercus incana* itself.

The following stages may be distinguished:—

1. Crustose lichen stage, beginning with little flecks of color on the bark when branches are 3–4 years old. Of the numerous pioneer crustose lichens, two species produce about 75 per cent. of the vegetation of this stage.

2. Foliose and fruticose lichen stage; starts almost as early as the crustose lichens, but begins to make a characteristic showing 3–4 years later. *Usnea barbata* is a prominent member. When this stage is fully developed, in 9–12 years under favourable conditions, the numerous species nearly or quite cover the branches.

3. Pioneer moss stage. Pioneer mosses (especially *Lindbergia pachytheca*) and a liverwort (*Frullania?* sp.) gain a foothold in favorable spots. Other trailing and erect mosses follow, gradually crowding out the lichens, probably by shading them.

4. Climax moss stage, when *Leucodon secundus*, *Diaphanodon blandus*, and *Cryptoleptodon flexuosus* develop a thick continuous pad about the branches. Under favorable conditions this stage is reached

in about 20 years. Lichens, with Myxophyceæ as the alga component, become frequent. A bed of soil from wind-borne dust particles gradually accumulates in the moss pad.

The greatest advance of the moss stage is indicated by the appearance of mesophytic mosses (as *Meteorium buchanani*), lichens (as *Sticta pulmonaria*), and liverworts (as *Porella*).

5. Fern stage. *Pleopeltis simplex*, the most xerophytic of the epiphytic ferns in the area, gains a foot-hold in the moss pad ; it is followed by *Leucostegia pseudo-cystopteris*, which forms the bulk of the epiphytic ferns observed about Landour. In protected humid places *Goniophlebium lachnopus* becomes common. The fern stems and roots collect and hold more dust, forming a soil bed that may attain a thickness of 10 cm.

Increasing density of shade of the leaves of *Leucostegia* gradually kills out the climax mosses, and in their stead small erect soil mosses appear, recalling the development of herbaceous vegetation on the floor of a dense shady forest. Some of these little mosses seem to be exclusively epiphytic.

6. Flowering plant stage—perhaps only the highest expression of a vascular plant stage. *Tripogon filiformis*, *Thalictrum saniculaforme*, *Sedum trifidum*, and *Begonia amoena* in order of importance, often become as prominent as the ferns. This is the climatic climax of the epiphytes in the Landour area.

Secondary successions are as common and well marked among epiphytes as among terrestrial plants. With increasing stem size and inevitable bark decay, moss pads slip off here and there, leaving patches of bare bark to be invaded by pioneer secondary succession mosses. Even the mat of vascular plant stems and roots may at times give way leaving bare spots.

Identification of species of lichens, liverworts and mosses is incomplete. Lichens are being identified by Miss ANNIE LORRAIN SMITH, Liverworts by Prof. SHIV RAM KASHYAP, and mosses by Mr. H. N. DIXON. To these persons I am deeply indebted.

About 45 species of lichens, 10 of liverworts, 50 of mosses, 5 of ferns, and 12 of flowering plants have been found in the various stages of the succession.

Details of succession, and composition of the various stages vary widely, depending on (1) exposure to wind, (2) bark characters of the trees, (3) position on the branches and position of branches on trees, and (4) on chance dissemination of the species involved.

Exposure retards succession, so that isolated exposed trees may progress no further than the foliose and fruticose lichen stage, while

trees in the most humid locations bear a luxuriant growth of quite mesophytic lichens, liverworts and mosses.

Physical and perhaps chemical, characters of the bark of the various trees are of great importance. *Rhododendron arboreum* bark flakes off so easily that succession rarely progresses to the climax moss stage and the species involved are somewhat different from those found on oaks.

Position of the branches and other features produce widely varying habitats even on the same tree. "Edaphic" spots, as the under side of branches, crotches, and nearness to the ground level, permit succession to proceed beyond the average for the tree.

Chance dissemination determines whether or not a particular species shall appear on a given tree. For example, it is very common to find some trees remaining for many years in the climax moss stage, while nearby trees are covered with ferns.

Seasonal differences in climatic conditions cause very large seasonal difference in the aspect, and probably also in the composition of the epiphytic flora. Lichens, liverworts, and most mosses simply dry up during dry whether, and revive and resume growth with each rain; nearly all the vascular plants remain alive only by means of perennating organs, and are conspicuous only during the summer monsoon; while little mosses in the shade of the vascular plants reach their maximum development in August and September. Further study is necessary to determine the extent and character of seasonal phenomena in the epiphytic vegetation.

Succession shown by epiphytes is considered to be unique, because of (1) the short time required for completion, (2) the unusual clearness of the successive stages, (3) the small size of the plants involved, and (4) the adaptation of the plants to repeated and prolonged dessication.

It is possible that further study of the succession of epiphyets may throw new light on the problem of succession in general, especially in a strongly periodic climate.

ON THE PROTANDRY OF THE FLOWERS OF AESCHYNANTHUS HOOKERI, CLARKE

BY

M. O. TIRUNARAYANA IYENGAR, B.A., F.Z.S.,
Entomologist Department of Public Health, Bengal, (Calcutta.)

The flowers of *Aeschynanthus Hookeri* Clarke (Pl. II.) were studied with reference to an interesting form of floral protandry. This species is very common on trees in the Darjeeling district from 4,000 to 8,000 feet above sea-level. It has very fleshy leaves, green above and yellowish green below, opposite, lanceolate, acuminate, very feebly serrate and obscurely nerved. The plants hang pendulously from the branches of trees and bear bright red flowers in terminal clusters. The calyx is long, tubular and 5-fid at tip. Corolla tubular, slightly bi-labiate and hairy. Stamens four, didynamous, the anthers of the upper pair fusing by their tips and so also those of the lower pair; anthers, oblong and opening by slits on the under side. Ovary superior.

In the bud, the stamens are well-developed, with stout oblong anthers; the pistil is very small, the style being much shorter than the ovary. When the flower opens the two pairs of stamens are well developed and are exserted to nearly an inch beyond the corolla tube; but the pistil is still very short and undeveloped. After the flower opens, the style grows and elongates rapidly and after three to four days reaches the mouth of the corolla (Pl. I. figs. 1 and 2). Its growth continues and after a few days more the tip of the style reaches the same position as the longer pair of stamens occupied when the flower opened (Pl. I. fig. 3). The stigma then gets well developed and at the same time the two pairs of stamens move ventrally and finally curl over the lower lip of the corolla (Pl. I. fig. 4).

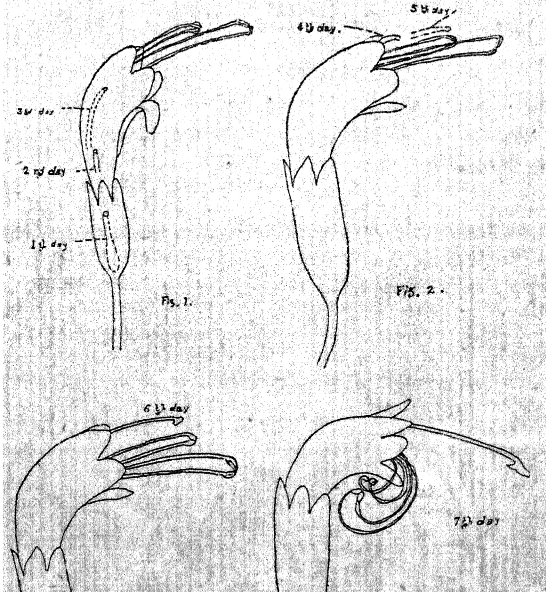
This remarkable example of protandry is apparently helpful in preventing self-pollination. It is in some ways similar to the protandry of the flowers of the Genus *Clerodendron*. In *Clerodendron*, the stamens ripen first and the stigma subsequently. When the flower opens the mature stamens project beyond the upper lip of the corolla while the style occupies a ventral position and curl over the lower lip of the corolla. When the anthers have opened and begin to shrivel the stigma ripens and the style and the stamens then change places;

and the stigma occupies the same position as did the stamens originally. The stamens then hang out of the lower lip of the corolla and wither. But in the case of *Aeschynanthus Hookeri* Clarke the style actually *grows* from a very minute condition to a great length after the opening of the flower. The stigma, besides not being mature at the time of the opening of the flower, is very far inside the tube of the corolla, quite out of the reach of pollen from the same flower.

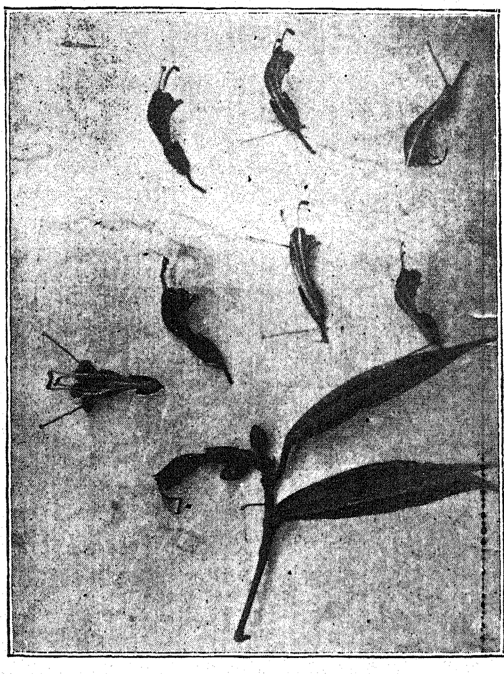
Summary

The flowers of *Aeschynanthus Hookeri* Clarke exhibit protandry in the following manner.—The pistil is very small at the time of the opening of the flower, though all the other floral parts are well developed. It then begins to elongate repidly and grows to nearly six times its original length in 5-7 days, at the end of which period the stigma also matures. The stamens at this stage curl away from the anterior position, as in *Clerodendron*.

PLATE I.



FLOWERS OF *Aeschynanthus Hookeri* CLARKE.

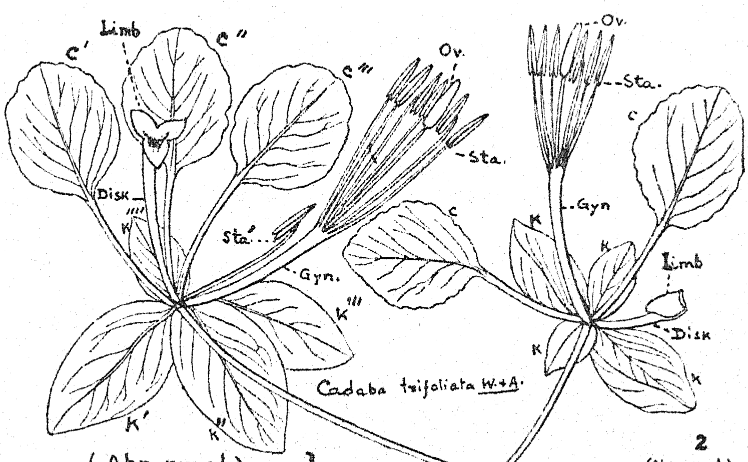


FLOWERS OF *Aeschynanthus Hookeri* CLARKE.

AN INSTANCE OF STAMINODY AND MULTIPLICATION OF PETALS, Etc. IN CADABA TRIFOLIATA W. & A.

By P. M. Debbarman,
Royal Botanic Garden, Sibpur.

Cadaba trifoliata *W. & A.*—a plant belonging to the N. O. Capparideæ—is a native of the Madras Presidency and Ceylon. Normally (see fig. 2), it has got palmately 3-foliate leaves and peculiar flowers consisting of 4 pale-green unequal sepals (**k**) in 2 whorls, 2 yellowish-white petals (**c**), a trumpet-shaped disk (Disk)



(Abnormal) 1

2 (Normal)

with tubular claw and bright-yellow recurved limb (Limb), 6 unilateral stamens (Sta.) on the slender gynophore (Gyn.) and a long-stalked one-celled ovary (Ov).

In 1916 Mr. C. E. C. Fischer collected at Sengaltero Ghat a flower-specimen (fig. 1) which was found to differ from a normal flower (fig. 2) in having three (**k′, k″, k‴**) out of the four sepals subequal, and three petals (**c′, c″, c‴**) and a stamen (Sta.) (in place of a missing petal), and also a large disk (Disk) with 3-lobed limb (Limb) having patent lobes. So, we have here an instance of *staminody* as well as *multiplication* of petals and of *enlargement* of the disk.

The writer is further informed by Mr. Fischer that the latter has come across specimens with leaves having leaflets varying in number from 1-5, thereby showing *leaf-variation.*

The writer has taken the liberty of putting this case on record as he has not seen Cadaba trifoliata mentioned in connection with the deviations noted above in any of the books and papers consulted by him.

Books and Papers Consulted.

Masters' Vegetable Teratology, (1869).

Annales Jard. Bot. Buitenzorg containing teratological papers by Messrs. Costerus, Smith and others.

THE FLORA OF SIND.

BY

T. S. SABNIS, B.A., M.Sc.

Continued from page 232.

XX. Rutaceae.

1. RUTA *L.*

1. **Ruta tuberculata** *Forsk. Fl. Aegypt. Arab. (1775) 86.* Loc.:—"Boogta hills (9)".

Distribution:—Baluchistan, Egypt, Algeria.

2. CITRUS *L.*

1. **Citrus aurantium** *L. Sp. pl. (1753) 782.*—The Orange. *Vern. Name*:—Naring.

Loc.:—Thar and Parkar: Mirpurkhas, Agricultural farm (Sab. B 713 !)

3. AEGLE *Corr.*

1. **Aegle Marmelos** *Corr. in Trans. Linn. Soc. V (1800) 223.*—*Vern. Name*:—*Bel.* Loc.: Thar and Parkar: Nasarpur (Sab. B 1143 !).

Distribution:—Commonly planted about the Hindoo temples in India.

Note.—Leaves are used in worship by the Hindoos. A kind of jam is prepared from the pulp of the fruit and is good against diarrhœa and dysentery.

XXI. Simarubaceae.

1. AILANTHUS *Desf.*

1. **Ailanthus excelsa** *Roxb. Cor. pl. I (1795) 24, t. 23.*—*Vern. Name*: Maharuk. Loc.:—Sukkur: Sukkur, forest nursery (Sab. B 430 !).

Distribution:—India (W. Peninsula), Ceylon, Cochin China.

XXII. Burseraceae.

1. GARUGA *Roxb.*

1. **Garuga pinnata** *Roxb. Hort. Beng. (1814) 33, Cor. pl. III, 5, t. 208.* Loc.:—Thar and Parkar: Mirpurkhas, water course (Sab. B 1026 !).

Distribution:—Throughout India, Malaya, Philippines.

2. COMMIPHORA *Jacq.*

1. **Commiphora Mukul** *Engl. in DC. Monogr. Phan. IV (1883) 12.* Loc.:—Karachi: Magho Pir (Sab. B 214 !). Thar and Parkar: Umerkot, sandy plains (Sab. B 726 !). Without locality (9).

Distribution:—Arabia, Baluchistan, Rajputana, Fl. and Fr.; October and November.

2. **Commiphora Stocksiana** *Engl. in DC. Monogr. IV (1883) 7* Loc.:—Without locality, hills and rocky places. (9).

Distribution:—Baluchistan.

XXIII. Meliaceae.

1. AZADIRACHTA *A. Juss.*

1. **Azadirachta indica.** *A. Juss in Mem. Mus. Par. XIX (1830) 221.*

Vern. Name: Nim. Loc.: Larkana: Laki, foot of the hill (Sab. B 12 !). Sukkur: Sukkur, forest nursery (Sab. B 416 !). Hyderabad: Ganja Hill (Sab. B 988 !), Thar and Parkar: Mirpurkhas, canal banks (Sab. B 860 !).

Distribution:—Cultivated throughout India and in many hot climates. Fl.: November.

XXIV. Celastraceae.

1. GYMNOSPORIA *Wt. and Arn.*

1. **Gymnosporia montana** *Benth. Fl. Austral. I (1863) 400.* Loc.: Karachi: Soorjana Hill 1800 ft. (Ticehurst 30883 !). Thar and Parkar: Umorkot, sand dunes (Sab. B 814 !). Without locality (9).

Distribution:—Central Africa, Afganistan Persia, Baluchistan. India, Malaya, Australia. Fl.: August—November.

XXV. Rhamnaceae.

1. ZIZYPHUS *Tourn.*

1. **Zizyphus Jujuba** *Lam. Encyc. III (1789) 318.*

Vern. Name: Bor. Loc.: Larkana: Larkana (Sab. B 448 !). Sukkur: Sukkur, road side (Sab. 8 419 !). Khairpur: Khairpur, Mirva canal bank (Sab. B 262 !) Nawabshah: Pad Idan (Sab. B 563 !). Hyderabad; Phuleli canal banks (Sab. B 161 !).

Distribution:—Africa, Afganistan, India, Ceylon, China, Australia. Fl.; October.

Note: varies considerably in armature, in shape of fruit and in size, shape and hairiness of leaf.

2. **Zizyphus trinervia** *Roxb. Hort. Beng. (1814) 17 (not of Poin).* Loc. :—Larkana: Laki, foot of the hill (Sab. B 741 !).

Distribution :—India.

3. **Zizyphus rotundifolia** *Lam. Encyc. III (1789) 319.* Loc.—Karachi: Manora Isl. (Sab. B 826 !); Gizri sands (Sab. B 784 !). Larkana: Laki, foot of the hill (Sab. B 130 !). Nawabshah, Pad Idan (Sab. B 560 !). Thar and Parkar: Nasarpur (Sab. B 1122 !); Mirpurkhas, water course (Sab. B 878 !); Jamesabad (Sab. B 1159 !); Umerkot, sand dunes (Sab. B 725 !).

Distribution :—Persia, India.

4. **Zizyphus horrida** *Roth. Nov. pl. Sp. (1821) 159.* Loc. :—Larkana: Larkana, ! coloured soil (Sab. B 38 !). Khairpur: Mir's forest (Sab. B 343! ; Mirva canal bank (Sab. B 261 !). Hyderabad: Kotri, Indus banks (Sab. B 407 !). Thar and Parkar: Mirpurkhas, water course (Sab. B 871 !); Sanghar (Sab. B 740 !).

Distribution :—India.

5. **Zizyphus rugosa** *Lamk. Encyc. 111* (1789) *319.* Loc. :—Hyderabad: "Hyderabad (9)".

Distribution :—India generally, Ceylon.

XXVI. Vitaceae.

1. Vitis *L.*

1. **Vitis vinifera** *L.* The Vine.

Vern. Name: Draksha.

Note.—Found cultivated on the Agricultural Farm at Mirpurkhas (Sab. B 832 !).

XXVII. Sapindaceae.

1. Cardiospermum *L.*

I. **Cardiospermum Halicacabum** *L. Sp. pl. (1753) 366.* Loc :—Without locality (9).

Distribution :—Rajputana and most warm countries.

2. Dodonaea *L.*

1. **Dodonaea viscosa** *L. Mantiss.* II (1771) 149. Loc. :—Without locality (9).

Distribution :—Baluchistan, India, Ceylon and in most warm countries.

XXVIII. Anacardiaceae.

1. Rhus *L.*

1. **Rhus mysurensis** *Heyne ex Wight & Arn. Prodr. (1834) 172.* Loc :—Karachi: Karachi (Ticehurst 28135 !); Soorjana hill 1800 ft. (Ticehurst 30877 ;). Without locality, on hills (9).

Distribution :—India. Fl.—August.

2. MANGIFERA *L.*

1. **Mangifera indica** *L. Sp. pl.* (*1753*) *200.*

Vern. Name: Amba. Loc. :—Sukkur: Sukkur forest nursery (Sab. B 425 !).

Distribution :—Cultivated as far west as Muscat, in all Eastern Tropical Asia, and generally in the tropics.

XXIX. Moringaceae.

1. MORINGA *Lam.*

1. **Moringa pterygosperma** *Gaertn. Fruct. II* (1791) 314.

Vern. Name: Shevga. Loc.: Larkana: Laki hill (Ticehurst 28120 !). Thar and Parkar: Mirpurkhas, fields (Sab. B 691 !); Sanghar (Sab. B 772 !).

Distribution :—Forests of the Western Himalaya and Oudh, cultivated elsewhere in India and in various tropical countries.

2. **Moringa Concanensis** *Nimmo, in Grah. Cat. Bo. pl.* (1839) 43. Loc.: Without locality (9).

Distribution :—Baluchistan, Rajputana.

XXX. Leguminosae.

I. PAPILIONACEAE.

1. ARGYROLOBIUM *Eckl. and Zeyh.*

1. **Argyrolobium roseum** *Jaub. and Spach. Illustra. I* (1842) 116 Loc.: "Bogata hills (9)". Without locality (9).

Distribution :—Persia, Baluchistan, India (N. W. Provinces).

2. LOTONONIS *Dc.*

1. **Lotononis Leobordea** *Benth. in Lond. Journ. Bot. II* (1843) 607. Loc.: Larkana: "Sehwan (9)". "Cultivated land between the plains and the Rohill pass (9)".

Distribution :—Egypt, Abyssinia, Perim, Syria, Arabia, Baluchistan, India (Punjab).

3. HEYLANDIA *Dc.*

1. **Heylandia latebrosa** *Dc. Mem. Leg.* (1825) 201. Loc.: Thar and Parkar: Jamesabad, fields (Sab. 908 !, B 915 !).

Distribution :—India, Ceylon. Fl. and Fr.: November.

4. CROTALARIA *L.*

1. **Crotolaria Burhia** *Hamilt. in Wall. Cat.* (1828) 5386. Loc.: Karachi: "Jamadar ka Landa (9)"; Karachi (Ticehurst 32285 !). Larkana. Sehwan,—Sand dunes (Sab. B 8666 !), Sandy plains (Sab.

B 943 !). Sukkur: "Shikarpur (9)". Nawabshah: Pad Idan (Sab. B 570 !). Thar and Parkar: Nasarpur, sand dunes (Sab. B 1134 !); Mirpurkhas—"(9)", (Sab. B 865 !, B 964 !); Jamesabad, fields (Sab. B 909 !); Sanghar (Sab. B 743 !); Umerkot, sandy plains (Sab. B 943 !). Without Locality (9).

Distribution :—Afganistan, Baluchistan, N. W. India, Gujarat. Fl. and Fr. :—October and November.

2. **Crotalaria medicaginea** *Lamk. Encyc. Method. II (1786) 201.*

Distribution :—Afganistan, Trop. India, Ceylon, China, Malaya.

Var. :—1. **neglecta** *Baker, in Fl. British India II, 81.* Loc. :—"Umrak (9)". Without locality (9).

3. **Crotalaria juncea** *L. Sp. pl. (1753) 714.* The Sun Hemp. Loc. :—Larkana: Larkana, fields (Sab. B 103 !).

Distribution :—Cultivated throughout India, Malay Islands, Australia. Fr. :—October.

5. TRIGONELLA *L.*

1. **Trigonella occulta** *Delile, Fl. Aegypt. Illust.* (1812) 71. Loc. :—Without locality (9).

Distribution :—Egypt, Nubia, India.

6. MELILOTUS *Juss.*

1. **Melilotus indica** *All. Fl. Pedem.* I *(1785) 308.* Loc. :—Without locality (9).

Distribution :—Europe, S. Persia, Afganistan, Baluchistan, and introduced in many other regions.

7. MEDICAGO *L.*

1. **Medicago lupulina** *L. Sp. pl.* (1753) *779.* Loc. :—Karachi: Karachi (Ticehurst 30864 !, 30871 !). Larkana: "Sehwan (9)".

Distribution :—Afganistan, Abyssinia, Mediterranean, Orient, India, (N. W.). Fl. :—August.

2. **Medicago laciniata** *All. Fl. Pedem. I (1785) 316.* Loc. :—Without locality (9).

Distribution :—Abyssinia, Egypt, Baluchistan, India.

3. **Medicago denticulata** *Willd. Sp. pl. III (1800) 1414.* Loc. :—Larkana: "Bhubak (9)"; "Sehwan (9)".

Distribution :—Europe, Abyssinia, Baluchistan, India, Orient, China, Japan, Siberia.

8. LOTUS *L.*

1. **Lotus corniculatus var. minor** *Baker in Hook. f. Fl. Brit. Ind. II (1876) 91.* Loc. :—Without locality (9).

Distribution :—Sind.

2. **Lotus Garcini** *DC. Prodr II (1825) 212.* Loc.:—Karachi: "Jamadar ka Landa (9)"; "sandy ground near the sea (9)". Without locality (9).

Distribution:—Through Persia to Nubia.

9. CYAMOPSIS *DC.*

1. **Cyamopsis psoralioidos** *DC. Prodr. II (1825) 216.*

Vern. Name: Gavar. Loc.:—Larkana: Larkana, cultivated (Sab. B 455 !) Hyderabad, cultivated (Sab. B 40 !). Thar and Parkar: Mirpurkhas, cultivated (Sab. B 692 !).

Distribution:—Cultivated in many parts of India, Afghanistan.

Uses:—Pods cooked and eaten as a vegetable.

10. INDIGOFERA *L.*

1. **Indigofera linifolia** *Retz. Obs. Bot. fasc. 4 (1786) 29 and fasc. 6 1791 t. 2.* Loc.:—Thar and Parkar: Jamesabad fields (Sab. B 1105 !).

Distribution:—Abyssinia, Afghanistan, India, Ceylon, N. Australia. Fl. and Fr.: November.

2. **Indigofera cordifolia** *Heyne ex Roth. Nov. pl. Sp. (1821) 357.* Loc.:—Karachi: (Ticehurst 30868 !) "(9)". Without locality (9).

Distribution:—N. Australia, Baluchistan, Afghanistan, India, Fl.: August.

3. **Indigofera trigonelloides** *Jaub. and Spach. Illustr. V. (1857) 92, t. 482.* Loc:—Karachi: "Jamadar ka Landa (9)"; "Mugger Peer (9)". "Boogta hills (9)". Without Locality (9).

Distribution:—Confined to Sind.

4. **Indigofera anabaptista** *Steud. Nom. ed. 2, (1840) 805.* Loc:—Karachi: "Mulir (9)". Without locality (9).

Distribution:—Afghanistan, Arabia, Rajputana.

5. **Indigofera paucifolia** *Del. Fl. d'Egypte (1812) 251.* Loc:—Karachi: Clifton sands (Sab. B 802 !); Magho Pir (Sab. B 207 !); Habb river (Ticehurst 30858 !); "Magho Pir (9)" Larkana: Larkana, coloured soil (Sab. B 452 !); Sehwan, coloured soil (Sab. B 30 !, B 595 !); Sita Road (Sab. B 366 !). Hyderabad Phuloli canal banks (Sab B 157 !); Kotri Indus Banks (Sab. B 369 !). Thar and Parkar: Nasarpur (Sab. B 1129 !); Mirpurkhas (Sab. B 951 :, B 959 ; B 1194 !); Sanghar (Sab. B 647 !, B 653 !); Umerkot (Sab. B 813 !). Without locality (9).

Distribution:—Trop. Africa, Arabia, Baluchistan, India, Ceylon, Java. Fl.: October and November.

Note:—Common on sandy plains and coloured soil.

6. **Indigofera articulata** *Goiian, Illustr. et. Obs. (1773) 49.* Loc.:— Without locality (9).

Distribution :—Egypt, Abyssinia, Arabia, Sind,—Cultivated for the Indigo.

7. **Indigofera tenuifolia** *Rottl. ex. Wt. and Arn. Prodr. (1834) 200.* Loc. :—Without locality (9).

Distribution :—India, Ceylon.

8. **Indigofera viscosa** *Lamk. Encyc. Method. III (1789) 247.* Loc. :—Without locality (9).

Distribution :—Sparingly throughout India, Ceylon.

9. **Indigofera argentea** *Burm. Fl. Ind. (1768) 171 (not of L.)* Loc. :—Karachi : "Jamdar ka Landa (9) ;" sandy soil near the sea (9); Clifton sands (Sab. B. 795 !). Larkana: Sehwan (Sab. B. 841 !). Thar and Parkar: Umerkot, sand dunes (Sab. B. 1069 !).

Distribution :—Abyssinia, Egypt, Arabia, Rajputana.

10. **Indigofera Houer** *Forsk, Fl. Aegypt.—Arab. (1775) 137.* Loc. :—Without locality (9).

Distribution :—Egypt, Abyssinia, Arabia, Baluchistan, India.

11. **Indigofera tinctoria.** 1. *Sp. pl. (1753) 751.*—Indigo plant.

Vern. Name : *Nil.* Loc. : Thar and Parkar : Mirpurkhas, water-course (Sab. B. 861 !, B. 1031 !).

Distribution :—Cultivated in many parts of India. Fl. and Fr. : October and November.

11. PSORELEA *L.*

1. **Psorelea plicata** *Delile, Fl. d'Egypte (1812) 252, t. 37. fig. 3.* Loc. :—Without locality (9).

Distribution :—Trop. Africa, Egypt, Arabia, India (Punjab).

12. TEPHROSIA *Pers.*

1. **Tephrosia tenuis** *Wall, Cat. (1828) 5970.* Loc. :—Karachi : Karachi (Ticehurst 30865 !, 30870 !) ; "Jamadar ka Landa (9)".

Distribution :—India, Laccadives. Fr. : August.

2. **Tephrosia coccinea** *Wall. Cat. (1828) 5633.* Loc. :—Karachi : Karachi (Ticehurst 28142 !, 28150 !).

Distribution :—India. Fl. : August.

3. **Tephrosia Apollinea.** *Link, Enum. Hort. Berol. II (1822) 252.* Loc. :—Without locality (9).

Distribution :—Egypt, Nubia, Abyssinia, Aden, Baluchistan.

4. **Tephrosia pauciflora** *Grah. in Wall. Cat. (1828) 5635.* Loc. :— Karachi : "Jamadar ka Landa (9) : Without locality (9).

Distribution :—Afghanistan, India.

5. **Tephrosia petrosa** *Blatt. and Hall. Journ. Bom. Nat. Hist. Soc. XXVI, Part 1 (1918) 239* Loc. :—Larkana : Laki, foot of the hill (Sab. B 285 !, B 619 !).

Fl. and Fr. October.

13. SESBANIA *Scop.*

1. **Sesbania aculeata** *Poir. Encyc. VIII (1806) 128.* Loc. :—Larkana : Larkana, fields (Sab. B. 445 ! B 466 !). Khairpur: Khairpur sandy plains (Sab. B 234 !). Nawbshah : Pad Idan (Sab. B 592 !). Hyderabad : Hyderabad, fields (Sab. B 47 !). Thar and Parkar; Mirpurkhas (Sab. B 706 !, B 957 !); Jamesabad (Sab. B 922 !): Sanghar (Sab. B 644 !).

Distribution :—Tropics of the Old World. Fl. and Fr.: October, and November.

14. ASTRAGALUS *L.*

1. **Astragalus prolixus** *Sieb. pl. Aegypt. exsicc. ex Bunge, Monogr. Astr. (1868—69) Part I, 9; Part 2, 6.* Loc. :—Without locality (9).

Distribution :—Cape Verd Islands, Egypt; Arabia, Punjab.

2. **Astragalus contortuplicatus** *L. Sp. pl. (1753) 758.* Loc. :—Hyderabad : " Hyderabad (9) ". Without locality (9).

Distribution :—E. Europe, Orient, Punjab, W. Siberia.

3. **Astragalus Stocksii** *Benth. ex Bunge, Monogr. Astr. (1868—69) Part 1, 6, Part 2, 4.* Loc. :—Larkana : " Kirthar Mountains (9) ".

Distribution :—Afghanistan, Baluchistan.

15. TAVERNIERA *DC.*

1. **Taverniera nummularia** *DC. Mem. Legum. (1825) 340, t. 52.* Loc. :—Karachi : Karachi (Ticehurst, 32294 !). Without locality (9).

Distribution :—Orient, Afghanistan, Baluchisten, India (Punjab.) Fl.: April.

16. ALTHAGI *Tourn.*

1. **Althagi camelorum** *Fisch. Ind. Hort. Gorenk. ed.* 2 (1812) 72. Loc. :—Karachi : Karachi (Ticehurst 32289 !). Larkana : Larkana,—coloured soil (Sab. B. 480 !), fields (Sab. B. 104 !, B. 486 !); Sehwan—"(9)", coloured soil (Sab. B. 598 !); Laki, foot of the hill (Sab. B. 10 !) Sukkur : Sukkur, coloured soil (Sab. B. 546 !). Khairpur : Khairpur (Sab. B. 229 !); Mirva canal bank (Sab. B. 260 !). Hyderabad : " Hyderabad (9)"; Kotri, Indus banks (Sab. B. 401 ! B. 405 !); Phuleli canal bank (Sab. B. 187 !). Thar and Parkar : Jamesabad, fields (Sab. 904 !, B. 1106 !); Sanghar (Sab. B. 631 !). Without locality (9).

Distribution. :—Egypt, Arabia, Baluchistan, India, Fl. and Fr.: October and November.

Note :—Very common on coloured soil.

(To be continued.)

TWO INSTANCES OF SHORT-CUTS BY ANIMALS TO THE NECTARIES OF FLOWERS.

BY

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The visits of animals to flowers are usually attended with benefits to both the animals and the flowers. The animal visitors get honey or pollen or both and in return, cross pollinate the flowers. But sometimes the animal visitor takes the honey without bringing about cross pollination. In fact it steals the honey. This it does by getting at the nectary not by the legitimate route—the open mouth of the flower—but by cutting or piercing the side of the flower, or sometimes even by cutting off entirely the portion of the flower above the nectary.

Cases of short-cuts to nectaries by various kinds of birds have been recorded in Europe by Darwin (**1**), Hermann Müller (**2**), Knuth (**3**), Swynnerton (**5**) and others, in Brazil by Fritz Müller (**2** : p. 75) and in South East Africa by Swynnerton (**4**). Knuth (**3** : vol. I, p. 77) says, "In Europe the visits of birds to flowers occur only exceptionally, and when they do, pollination does not take place by way of recompense, for the birds only work havoc. Thus Hermann Müller (Nature IX, 1874, pp. 482, 509; X, 1874 pp. 6, 24; XIII, 1876, p. 427; XV, 1877, pp. 8, 41, 84, 163,) saw sparrows pecking off the flowers of the yellow crocus, and bullfinches biting out of primroses with hereditary skill exactly that section of the lowest part of the flower which contains the nectar."

Two instances of short cuts to nectaries from South India, one by a bird and the other by an insect, have come under the observation of the author and are described here below.

* Sun-birds and flowers of the Rangoon Creeper.

The flowers of the Rangoon Creeper (*Quisqualis indica L.*) have a tubular calyx about 2 inches long. The honey is secreted in the calyx tube to about two-thirds of its length from the bottom. The author observed at Madras some sun-birds (*Arachnechthra lotenia*) visiting these flowers. Since the beak of the bird was only about

* An account of this instance was read by the author before the Indian Science Congress meeting at Calcutta, 1921, February.

1 inch long and not long enough to reach the honey in the calyx tube through the natural opening of the flower, it bit a hole near the base of the calyx tube and sucked the honey contained in it. On examining the creeper, the author found that in each of its inflorescences a number of flowers was found cut like this at the bottom (Pl. I, 2, 3 and 4.) Even unopened flowers were robbed of their honey in this way (Pl. I, 5).

This habit seems to be fairly common among these birds in Madras, for the author has seen flowers of this plant similarly damaged in other parts of the city also. Sometimes the birds are not so skilful at their work. They bite holes in the calyx tube in a random manner at various levels and even cut off entirely the upper part of the flower (Pl. II and III). Perhaps these are only beginners and may attain greater skill at the work later on.

In this connection it may be mentioned that in Africa, too, Swynnerton (4) has observed sun-birds stealing honey from flowers. According to him the birds made these cuts into the flowers if the position of the latter on the plant is inconvenient. So, in the case of *Quisqualis indica*, it is quite possible that, besides the shortness of the beak of the bird, there may be another reason for the bird's resorting to the short-cut, *viz.*, the inconvenient position of the flowers, which hang loosely at the ends of the branches.

Carpenter-bees and Larkspur flowers.

The author observed in May, 1922, a carpenter-bee, (*Xylocopa sp.*) visiting a number of Larkspur (*Delphinium sp.*) flowers in the Government Botanical Gardens, Ootacamund (Nilgiris). The bee after alighting on the flower, climbed on to the upper part of its spur and, sitting on it with its head turned towards the tip of the spur, pierced its wall with its proboscis, which it then introduced inside and probed first one side and then the other and extracted the honey secreted in the two spurs of the upper petals inside the outer spur. This process was systematically repeated by the bee with every flower it visited. I then examined the Larkspur flowers in other parts of the garden and found that the spurs of many of these also were pierced likewise.

I must mention, in this connection, that Larkspur flowers have been known to be victims of such robbery by insects in Europe. Knuth (**3**: vol. II, p. 46) says with reference to *Delphinium elatum* L., " In the Riesengebirge, Schulz noticed holes in the spurs that had no doubt been made by thieving short-tongued bees." He (**3**: vol. II, p. 47) also says with regard to *D. Ajacis* L., "As a nectar-thief, I now and then noticed *Vanessa Io*. L." Hermann Müller (**3**: p. 86) says with reference to *D. consolida* L., " I have noticed *Satyrus* and species

of *Hesperia* sucking at the flowers, and sinking their thin proboscides into the spur, but apparently they did not touch the anthers or the stigmas."

With regard to the stealing habit of the carpenter-bee, Fritz Müller (See (2) p. 75) refers to carpenter-bees in Brazil stealing honey by boring. He, writing to F. Ludwig (Bot. Centralbl. lxxi, 1897, pp. 301-302) on humming-birds, says, "Frequently (like the largest of our bees, a *Xylocopa*, they steal the nectar by boring." Swynnerton (4: p. 382) says that his friend, Mr. G. A. K. Marshall, in Africa has frequently watched carpenter-bees slitting the flower-bases and stealing the honey.

A word as to the nature of the holes made in *Quisqualis* and *Delphinium* flowers by the sun-bird and the carpenter-bee respectively may be mentioned. In the case of the *Quisqualis* flowers the holes were made not by piercing, but by biting or rough pinching with the beak. Since the calyx-tube is very narrow and since the flowers do not offer much resistance, it is not easy for the bird to pierce them with its beak. So it makes a hole by biting or roughly pinching the calyx tube. In the case of the Larkspur, however, the hole is made by piercing. For the bee is able to get a good hold of the spur with its legs and thus is able to pierce it quite easily.

Thus it is very interesting to find that this habit of honey stealing from flowers is prevalent among birds and insects in different parts of the world and that almost the same birds, (sun-birds), should have developed this habit in such widely separated areas as South-East Africa and South India and almost the same insects, (carpenter-bees), in Brazil, South-East Africa and South India. Probably the phenomenon is much more prevalent among flower-visitors in India than we are aware of and, if naturalists should interest themselves in this phenomenon, many more instances of the kind will probably be recorded.

Literature.

1. Darwin, C.—Correspondence in Nature on the subject between 1874 and 1877.
2. Knuth, P.—Handbook of Flower Pollination, Eng. Trans. 3 vols.
3. Müller, Hermann.—The Fertilisation of Flowers. Eng. Trans.
4. Swynnerton C.F.M.—On short-cuts by birds to nectaries. Journ. Linn. Soc. Bot. Vol. XLIII, 1916, p. 381.
5. Do. —Short cuts to nectaries by Blue Tits. *ibid* p. 417.

Explanation of the plates.

PLATE I.

1. An uncut flower of *Quisqualis indica* L.
2, 3 and 4. Flowers of *Quisqualis indica* L. showing the cuts made by sun-birds in the calyx tube.
5. An unopened flower also is cut likewise.

The arrow marks show where the cuts are made.

PLATE II.

Flowers of *Quisqualis indica* attacked in a random way, probably by birds new to this work.

1. An uncut flower.
2—9. Flowers the whole upper parts of which have been cut off. Note the different levels at which the upper parts have been cut off.
10 and 11. Flowers with holes cut at different levels.

PLATE III.

The same as the above with the cut flowers on the shoots.

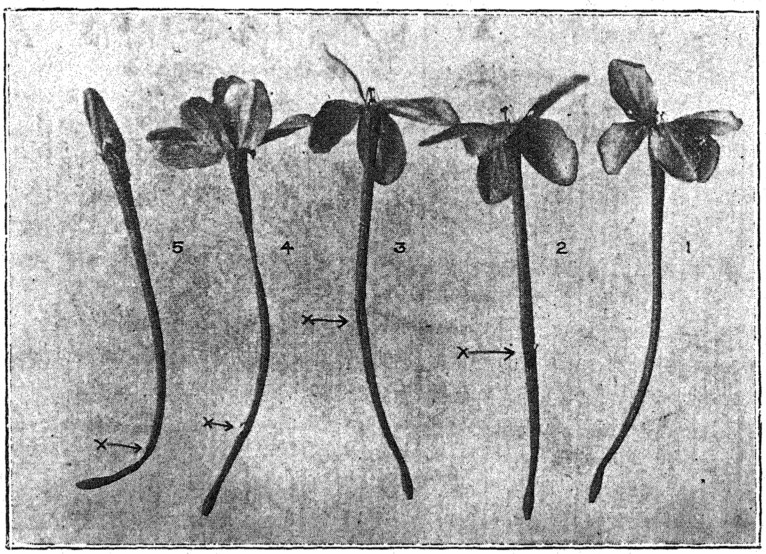

PLATE I.

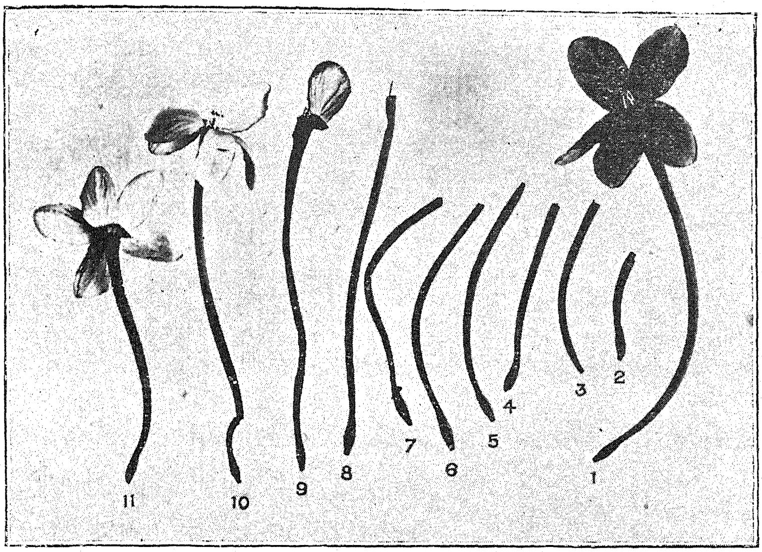

PLATE II.

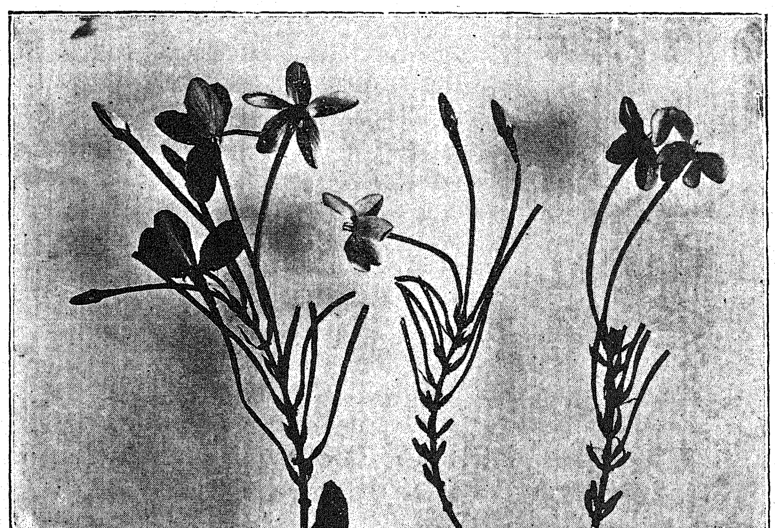

PLATE III.

NOTE ON A BULBIFEROUS COCOANUT TREE FROM MALABAR

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Some years ago the author received some specimens of bulbils of a cocoanut tree which was growing in Malabar, South India. The tree, it was reported, did not at any time bear any flowers or fruits. But in the place of each inflorescence a leafy bud or bulbil was formed. These leafy shoots grew for some time and had the appearance of small young cocoanut plants. The shoots, owing to their weight, kept hanging downwards. A number of such shoots in various stages of growth was found on the tree. The shoots after reaching a certain size ultimately dropped off.

Ridley (4) has described a bulbiferous Cocoanut tree from Lemut, in the Dindings, and has given a photograph of the tree and a sketch of a bulbil. His description of the tree agrees entirely with that of this Malabar tree.

I tried to grow some of these bulbils in the ground, but they did not strike root and so died. The same was attempted, I heard, at Calicut (Malabar) with a similar result.

The bulbils in their young condition have more or less the same appearance as of a young unopened Cocoanut inflorescence enclosed in its spathe. When this bud is closely examined, it is found to consist of a number of scaly leaves on the outside enclosing more and more fully developed leaves inside. The first leaf corresponding in position to the spathe had fallen off, but the outermost leaf of the bud was a hard and leathery scaly leaf and resembled the spathe. The next few leaves resembled the outermost one, but showed some rudiments of a few leaflets at the top, and the next ones still more so and thus gradually led to the fully formed leaves in the centre of the bulbil.

The lamina portion at the top of the outermost leaves was not pinnate. The leaflets were standing side by side on the top of the scaly lower portion and were united together at their sides. The rachis had hardly developed (Pl. I. figs. 1, 2 and 3). The lamina portion here must be described as palmate, with the leaflets still

coherent at their sides. But the lamina portions of the inner leaves were more and more pinnate (with the rachis more and more developed), and finally those of the innermost leaves were well developed and resembled those of the fully grown tree, though the leaves were somewhat smaller in size. (see Pl. 1, fig. 4 and II).

Petch (3) has described from Ceylon a similar bulbil of the Cocoanut tree, but the leaves of his bulbils possessed only simple lamina with the leaflets joined together as in a young seedling. In the bulbils described in this note, the inner leaves were well developed and resembled those of the full grown tree, though the outer leaves resembled those of Petch's bulbils. In the bulbil figured by Ridley (4 : Pl. XXXVIII) the inner leaves are fully developed. But the outer scaly leaves, however, do not show at their tips the rudiments of the lamina as seen in the bulbils described here.

There is thus to be seen in the bulbils described here a gradual transition from the spathe-like outer leaves to the fully formed innermost leaves. The spathe of the cocoanut inflorence may therefore be considered—it is presumed that the outermost leaf of the bulbil resembled the spathe—as morphologically equal to a fully grown cocoanut leaf in which the lamina portion has not developed.

According to Arber (1), the Monocot leaf is simply the expanded petiole of an ordinary leaf, the lamina portion having been lost in the course of evolution. And the lamina portion of a Palm leaf, *i.e.*, the "fan" or "feather" limb, is, according to her (2), therefore, not morphologically a lamina, but only a modification of the distal region of the true petiole. She says "I thus regard the Palm leaf as a whole, as a petiolar phyllode and its blade as a pseudo-lamina, analogous to, but not homologous with, the blade of a Dicotyledon." Then, according to this view, the spathe of the cocoanut inflorescence would be morphologically equal to only a part of the original petiole (the lower part) and not the whole of it.

My thanks are due to Mr. V. Govindan Nair, of the Calicut High School, for his kindness in sending me the specimens of the bulbils and for giving me an account of the tree.

Literature.

(1) Arber, Agnes. The Phyllode Theory of Monocots. Ann. Bot. XXXII, 1918 pp. 465—501.

(2) Do. On the Development and Morphology of the leaves of Palms. Proc. Roy. Soc. B. Vol. 93, 1922, pp. 249—61.

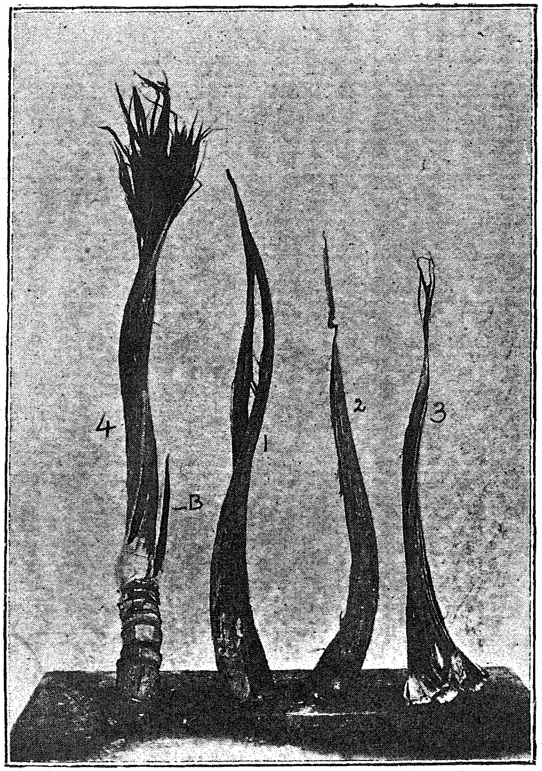

PLATE I.

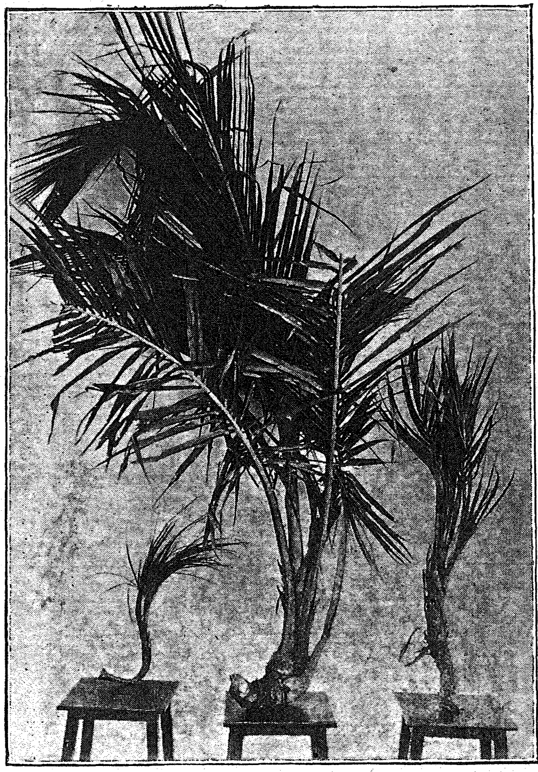

PLATE II.

(3) Petch, T. Abnormalities of the Cocoanut Palm. Ann. Roy. Bot. Gard. Peradenya, Vol. VI, (1915-17), pp. 25-29.

(4) Ridley, H. N. Branching in Palms. Ann. Bot. Vol. XXI, 1907, p. 415.

Explanation of the Plates.

Plate I.

A young cocoanut bulbil with three of its outer leaves removed and placed at the side.

1. Outermost leaf, showing the rudiments of the lamina at the tip. The scaly leaf was torn in the middle.

2 and 3. Next inner leaves with the lamina rudiments better developed.

4. The bulbil with the next inner leaves whose lamina portions have become somewhat pinnate, with the rachis well developed. An axillary bud, B, is seen at the side.

Plate II.

Three cocoanut bulbils: the middle one has got big fully developed leaves.

A CRITICAL NOTE ON CROTALARIA MADURENSIS *W.* AND C. CANDICANS *W. & A.*

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The name C. madurensis was, according to Cooke's Bombay Flora (Vol, I, p. 301), first applied in the year, *1828* by Dr. R. Wight to Wall. Cat. No. 5376.

Later on, in *1834* Wight and Walker-Arnott described the two species mentioned above in their "*Prodromus Florae Peninsulae Indiae Orientalis*" (Vol. I p. 184). The characters which they relied on for distinguishing the two are shown below side by side :—

C. madurensis *W.*	C. candicans *W. & A.*
"Covered all over (except the flowers) with *white* hairs, shaggy on the branches, close pressed and silky on the leaves."	"Covered all over with *fulvous* hairs."
"Bracteas *ovate, pointed.*"	"Bracteas *reniform.*"

In 1843 Bentham in his "*Enumeration of Leguminosae indigenous to S. Asia, etc.*", published in Hooker's "London Journal of Botany" (Vol. II), retained the two species as distinct, and based the distinction on the length of the legumes. On p. 564 he openly stated that the latter species was "unknown" to him.

In *1864*. Drury in his compilation. "*Handbook of the Indian Flora*" (Vol. I, p. 263)—reproduced, with slight alterations, the descriptions of these two species as originally given in Wight and Arnott's "Prodromus" mentioned above.

From the "*List of Plants of Peninsular India contained in Dr. Wight's Herbarium* distributed at the Herbarium, Royal Gardens, Kew, 1869-1870" (p. 8) it appears that even then C. madurensis and C. candicans used to be looked upon as different species and were distributed as such.

But a different note was struck for the first time by Mr. J. G. Baker in 1876. In Vol. II of the "*Flora of British India*" he published an account of Indian Crotalarias in which he gave a comprehensive description of C. madurensis and regarded C.candicans as only a synonym of the former.

It appears from Vol. I of the "*Index Kewensis*" published in 1895 that the editor accepted Mr. Baker's opinion.

In 1903 Dr. T. Cooke in his "*Flora of the Presidency of Bombay*" (Vol. I. p. 301) gave a detailed description of C. madurensis and

evidently agreed with Mr. Baker as regards the reducibility of C. Candicans to C. madurensis.

It appears from Prof. Fyson's "*The Flora of the Nilgiri and Pulney Hill-tops*" (Vol. I. p. 108), published in 1915, that he too agrees with Baker and Cooke.

From the short history given above it will be quite clear that, although originally Wight and Arnott regarded C. madurensis and C. candicans as distinct, some of the later authors were inclined to regard C. candicans as only a form of the former.

In 1915 Mr. J. S. Gamble in his "*Flora of the Presidency of Madras*" (Vol. II. p. 298) has, however, thought it advisable to discard the view held since 1876 and revert to the view originally held by Wight and Arnott. Accordingly, he has re-instated C. candicans to its former specific rank and has looked upon it as only *partly* synonymous with C. madurensis *of F.B.I.* II. 79. In the analytical key provided by him, he has mentioned the following distinguishing characters :—

C. MADURENSIS W.	C. CANDICANS. W. & A.
Bracts and bracteoles.—Ovate-acuminate, more or less *deciduous*, spreading, *not shining and black* (when dry) on upper surface.	Broadly cordate, acute *persistent*, *shining* viscous and *black* (when dry) on the upper surface.
Calyx-lobes.—*Not* prominently *resolute*.	Prominently *resolute*.

Attention should be drawn here to the fact that the specific characters mentioned above are different from those originally relied on by Wight and Arnott.

Now, taking into consideration the totality of characters mentioned above, if, Herb. Wight (Kew Distrib.) No. 604 approved by Mr. Gamble) be regarded as a co-type sheet of C. madurensis, then it will be found that, Wall. Cat. 5376 (quoted as type sheet)—as represented in Herb. Cal.—consists of two different specimens. Of these two, only the smaller leafy branch on the upper right-hand corner seems to belong to C. madurensis, the other (lower specimen) agreeing fairly well with some sheets named C. candicans by Mr. Gamble. The writer is inclined to think that the following sheets (now referred to C. madurensis), which are neither uniform in character, nor seem to be extreme forms of C. madurensis, should properly be referred to C. candicans (as described in the Madras Flora) :—

E. Neelgherries Schmid, No nil, (1834) ; Neelgherry, Wight (ex Herb. Dalzell), No. nil, (1874) ; Neeglherry,

Wight, Kew Distrib. No. 603, (1850); Nilgiris, Beddome, No. nil; Conoor, Meebold, No. 11957, (1910).

It will not perhaps be out of place to mention here that a gradual *transition* from C. madurensis to C. candicans, as described in the Madras Flora, will, in the opinion of the writer, be noticed if the Herb. Cal. specimens of C. madurensis are taken in the following order, *viz*:—

Bot. Gard. Calcutta, introduced from Neelgherries (a very old sheet but without the collector's name and number); Gudalur (Neelgherries), Meebold, No. 11586, (1910); Hort. Bot. Cal., (an old sheet but without any other particulars); Gudalur, Meebold, 11586 (Dupl. sheet), (1910); Herb. Wight Kew Distr. No. 604, Wall, Cat. 5376 (lower specimen); E. Neelgherries, Schmid, (1834); Coonoor, Meebold 11957, (1910) Herb. Wight Kew Distrib. No. 603, Neelgherry, (1850); Nilgiris Beddome, (no date or number given); Neelgherry, Wight, (ex Herb. Dalzell) (1847).

Similarly under C. Candicans the writer has noticed that C. B. Clarke's No. 10697 B (with smaller and fewer leaves) from Coonoor, agrees fairly well with Herb. Wight (Kew Distrib.) No. 603 and the Neelgherry sheet (ex Herb Dalzell), already referred to under C. madurensis. Now, if No. 603 and the Herb. Dalzell sheet be referred (as done by Mr. Gamble) to C. madurensis, then Clarke's No. 10697 too should necessarily either be referred to that species or both should go under C. candicans, if the latter is really separable from the former. It is also very doubtful that, if Herb. Wight (Kew Distrib.) No. 604 mentioned above be referred (as has been done by Mr. Gamble) to C. madurensis, whether Mr. Gamble's No. 16776 from Devashola (Nilgiris) can reasonably by referred to C. candicans. The Nilgiri and Kurg (Coorg) specimen (ex Herb. Ind. Or. Hf. & T.) too was found to agree with Meebold's No. 11957 mentioned under C. madurensis.

A question that naturally suggests itself at this stage is:—Are C. madurensis and C. candicans really two distinct species? The answer to this question naturally rests upon the solution to another important question :—What is meant by the term ' species '?

According to *Bentham* " A 'species' comprises all the individual plants which resemble each other sufficiently to make us conclude that they *are* all, or *may have been* all, descended from a common parent. These individuals *may often differ from each other in many striking particulars*, such as the *colour* of the flower, *size* of the leaf, etc., but these particulars are such as experience teaches us as are liable to vary in the seedlings raised from one individual. " (Handbook of Br. Fl., Introd. p. 26).

J. D. Hooker too has accepted and quoted this view. (Fl. Br. Ind., Vol. I, Outlines of Bot., p. 24. sect. 177).

According to *Mr. R. S. Hole* " A " species' is the smallest group of plants existing *wild* in nature which can be *readily distinguished* from all other groups owing to the fact that the individuals composing it all possess in common certain well marked characters (specific characters) by which they can be distinguished from all other plants. The individuals also which compose the species are, when developed normally in a state of nature, always able to transmit their specific characters unchanged to the majority of their immediate offspring ". (Manual of Botany, p. 120).

To determine whether C. candicans really deserves specific rank it will have to be observed whether it satisfies the conditions set forth in the above definitions.

The writer doubts very much if C. candicans is at all *readily* distinguishable from C. madurensis in the field. The writer will, therefore, be obliged if some of the S. Indian botanists, who have better opportunities than the writer, will take up the question and clear up, by systematic observations in the field, the anomaly pointed out above. Attention is invited in this connection to the species Nos. 52-60 of Madras Flora.

It may not be superfluous to repeat here Bentham's following remark—" When two supposed species grow together intermixed with numerous intermediates bearing good seed, and passing more or less gradually from the one to the other, it may generally be concluded that the whole are *mere varieties* of one species." (Handbook of Br. Fl., Introd., pp. 22-32).

Considering what has been stated above it seems to the writer that, the view put forward by Mr. Baker in Fl. Br. Ind. is probably the more reasonable one and that C. candicans is only a form or at most only a variety (according to Bentham's idea) of C. madurensis. It is a well-known fact that parts of plant specimens undergo, in more or less degree, changes in colour according to the time spent and the process employed in drying. So, no very great reliance can, in most cases, be put on their colour on drying.

In conclusion, the writer would like to add here that it should be borne in mind that the section 'Eriocarpeae', to which C. madurensis and C. candicans belong, is one of the most difficult groups, and the enormous difficulty the indefatigable worker Mr. Gamble had in properly arranging the S. Indian material at his disposal should be realised. The value of his contributions, which are the outcome of his life-long intimacy with Indian plants, should be fully appreciated and nothing in this paper should be construed to be little the valuable service Mr. Gamble is rendering to Indian Botany.

A PECULIAR BULB OF ALLIUM SATIVUM *LINN.*

BY

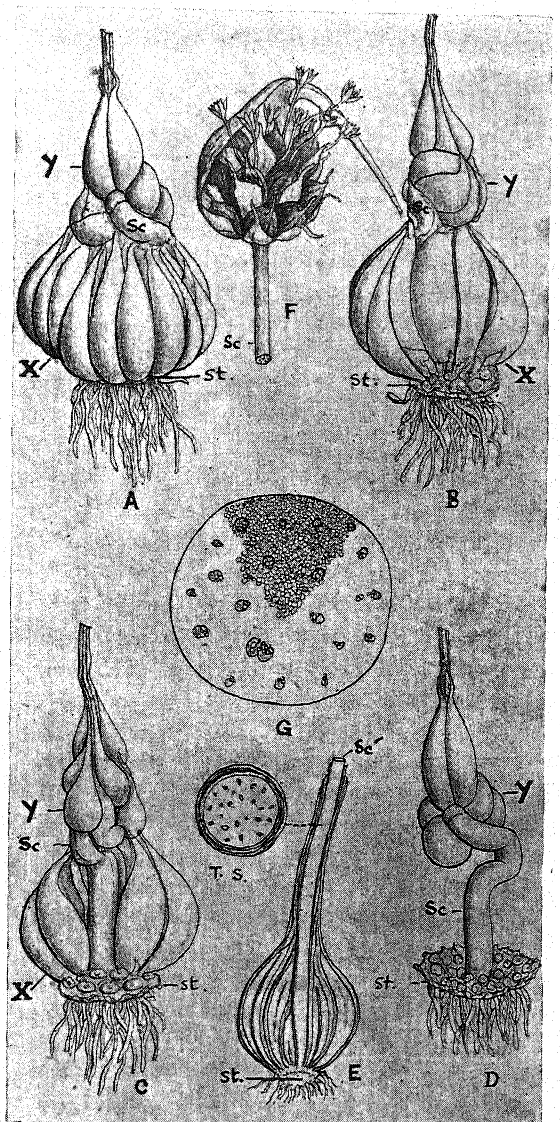
P. M. DEBBARMAN,

Royal Botanical Gardens, Calcutta.

In the course of a further search for teratological specimens, the writer has lately come across a peculiar bulb (figs. A-D) of Allium sativum L. It differs from a normal bulb (E) in having a small supernumerary bulb (Y) composed of a few bulblets, nicely fitted to the top of a large primary bulb (X) consisting of severel bulblets. On detaching some of the bulblets from the primary bulb (X) it was found that the bulblets of the supernumerary bulb (Y) were attached to the upper part of a curved prolongation (Sc) of a short discoid stem (St) hidden from view.

The question that naturally suggests itself here is—What has given rise to the supernumerary bulb (Y)? At first sight one is apt to take it as an instance of 'Displacement of bulbs' (1) possibly due to luxuriant growth. But, considering the normal size and shape of the primary bulb (X) and of the bulblets composing it, and the absence of any bulblets on the intervening portion of the scape (Sc) between the bases of X and Y, it seems hardly probable that there could have been present any cause leading to overcrowding and ultimate displacement of the bulblets to the position occupied by Y.

It is, however, a well-known fact that, even in a normal inflorescence of Allium sativum the flowers are sometimes mostly supplanted (2) by bulbils (see fig. F). These bulbils are hardly distinguishable (3) from the ordinary bulblets composing a normal bulb. It seems quite probable that, being placed under some adverse circumstance (*e.g.* storage during the flowering season) the primary bulb (X) could not get sufficient nourishment to give rise to a normal-sized scape bearing a normal inflorescence. It stands to reason that under unfavourable circumstances a plant will naturally prefer to take recourse to the vegetative instead of the sexual mode of reproduction, there being no facility for the latter to come into play. It was probably in this way that the flowers on the abortive inflorescence (Y) were totally replaced by bulblets, which were quite well-suited for the former mode of reproduction. The zigzag shape of the scape (Sc) seems to lend support to this view.



Allium sativum L.

The writer is inclined to look upon the prolongation (Sc) of the stem (St) as a scape, because, on sectioning (fig. G), it was found to be solid like the normal scapes (T.S. in fig. E) of Allium sativum. It will not perhaps be out of place to mention here that the bulblets in the supernumerary bulb (Y) seem to be analogous to the 'gemmae' met with in some species of Lycopodium (4).

The writer has not seen anything like this specimen described or figured before in any of the books and papers consulted by him. He, however, regrets that he could not find an opportunity of consulting Penzig's Pflanzen-teratologie and Worsdell's Principles.

Books and Papers consulted.

(1) Masters.—Vegetable Teratology (1869).

(2) and (3) Bentley and Trimen.—Medicinal Plants. Vol. IV. (1880) t. 280 and the notes thereon.

(4) Gœbel.—Organography of Plants—Vol. II (1905) pp. 467-469.

(5) Ann. Jard. Bot. Buitenzorg for teratological papers published therein.

Explanation of figures.

A. B.—Views of the abnormal specimen from opposite sides. Outer scales removed. Natural size.

C.—View with some of the front bulblets of the primary bulb (X) removed.

D.—Same as C, but with all the bulblets of the primary bulb removed.

E.—A longitudinal section of a normal bulb with scape (Sc.) and a transverse section (T.S.) of the scape.

F.—A normal inflorescence in which some of the flowers have been replaced by bulbils. (ex Bentley and Trimen's Med. Pl. IV.)

G.—Transverse section of the structure (Sc.) partly drawn.

NOTICE

The following letter and Provisional Programme of the Imperial Botanical Conference, London, 1924 have been received :—

Imperial Botanical Conference, London, July, 1924.

SIR DAVID PRAIN, F.R.S.,
Chairman of Executive Committee.

DR. A. B. RENDLE, F.R.S.,
Treasurer.

MR. F. T. BROOKS, M.A.,
Secretary.

31, TENISON AVENUE,
Cambridge,
21st July, 1923.

DEAR SIR OR MADAM,

I write to inform you that the Imperial Botanical Conference will be held from July 7th to July 16th, 1924, at the Imperial College of Science and Technology, South Kensington, London. The subscription for attending the Conference will be one pound, which I shall be glad to receive if possible with your intimation to be present.

A copy of the provisional programme is enclosed. The last two or three days of the Conference will be devoted to excursions to places and institutions of botanical interest. Many suggestions made by overseas botanists have been incorporated in the provisional programme, but I shall be pleased to receive any further comments thereon and to hear which of the discussions you would like to take part in. Will you also kindly show this letter and programme to any botanists who may not receive a copy ?

Yours faithfully,
F. T. BROOKS,
Secretary.

Imperial Botanical Conference, 1924.

PROVISIONAL PROGRAMME.

Discussions will probably be arranged upon the following topics amongst others :—

1. SYSTEMATIC BOTANY AND ECOLOGY.—
   (*a*) The best means of promoting a complete botanical survey of the different parts of the Empire.
   (*b*) Correlation of taxonomic work in the Dominions and Colonies with work at home.
   (*c*) Training in field ecology.

(*d*) Outline accounts of vegetation survey in different parts of the Empire.

2. GENETICS.—

(*a*) The economic possibilities of plant breeding.
(*b*) The value of selection work in the improvement of crop plants.

3. PLANT PHYSIOLOGY.—

(*a*) Recent work on crop physiology.
(*b*) The scientific problems of fruit storage, especially of fruit in transit overseas.

4. PLANT PATHOLOGY.—

(*a*) Obscure plant diseases of widespread occurrence.
(*b*) The relation of genetics to plant pathology.

5. EDUCATION AND RESEARCH.—

(*a*) The possibility of promoting:—

(*i*) Temporary exchanges of botanical posts in different parts of the Empire.

(*ii*) The interchange of Post-graduate students between the overseas and home Universities and Research Institutions.

(*b*) The desirability of providing further facilities for botanical research in the tropics and Dominions.

6. MISCELLANEOUS.—

(*a*) The paleobotanical resources of the Empire.
(*b*) Wood Technology. (*e.g.* Fungal attacks on wood and the preservation of timber).
(*c*) Nomenelature. (Expression of opinion on Rules of Nomenclature).
(*d*) Joint Conferences with other bodies. (*e.g.* Legislation *re* plant diseases especially as regards the control of plant imports).

The Conference will also provide a convenient opportunity for the reading of papers and the delivery of lectures by experts upon recent advances in Botany, pure and applied.

CURRENT LITERATURE.

Ecology

Champion H. G., The Influence of the hand of man on the distribution of Forest Types in the Kumaon Himalaya. *Indian Forester Vol. XLIX. No. 3. (March, 1923).*

Dividing the forest section of the outer Himalayan hills in the central parts of Kumaon, floristically into seven types, Shorea robusta (Sal), Low evel miscellaneous, Pinus longifolia, Quercus incana, Q. dilatata, Q. semicarpifolia, and Abies Pindrow, the author describes the characteristic qualities which give to each species dominance in its own area, and the differential effects of fire, felling, grazing and removal of leaves, where the species intermix on their boundaries. Sal stands fire extraordinarily well, for it is protected by a thick bark and the removal by fire of dead leaves and undergrowth, assists regeneration. But the author points out, by the consequent slowing down of the natural change from xerophytic to mesophylic conditions the increase of Sal forest is restricted.

The most interesting and important contact is between Pinus longifolia (chir) and Quercus incana (Banj). The former grows taller, but is ordinarily prevented from regeneration by the thick undergrowth of the oak. Long continued lopping and felling of the oak results in the soil becoming drier, and give the chir a better chance. But where the pressure of population is very intense the constant removal of dead leaves and litter reduces the number of fires, and by the continual cutting down of young poles for firewood or building the pine is eventually cut out, while the oak with wonderful powers of resistance survives. Thus heavy destruction by man leads to the replacement of the pine forest by one of scrub oak. In the end however the chir (Pinus) will disappear too.

An interesting point is the tendency for the oak when ill-treated to develop twisted fibres, so that the wood is "difficult to split and worthless as timber, with the result that such trees are spared. The author appears to consider that this tendency has become established and is heritable, so that a permanent alteration has resulted. But the inheritance of acquired characters is a very dubious proposition.

Summing up, the author finds the action of man is in general towards destruction of forests, denudation of hill sides, a favouring of sal in low areas, the extension of pine upwards into oak, and of lower oaks into the higher, and the restriction of his highest zone—that of the silver fir.

The paper is an interesting one, and its general theses are no doubt of wide applicability.

P.F.F.

Fungi

Bose, S. R. Trametes cincta, a new species of Polyporaceae, is described in *Bulletin* de la Société mycologique de France *Tome XXXVIII, 3e. Fascicule (1922).*

Morphology

Neitsch, E. Die morphologische Natur der Ranken der Cucurbitaceen. *Fedde Rep. Sp. Nor. Beih-Band XVIII*, 1923 *p.* 1-50 + *VII. pl.*

In this monographic study the author after summarising the various theories about the morphology of the tendrils of the Cucurbitaceæ discusses in separate chapters (1) the arrangement of organs at a node (2) side-shoot (3) the inflorescence (4) the tendrils and (5) the abnormalities, and arrive at the following conclusions.

The normal tendril of the Cucurbitaceæ is a composite organ made up of modified phyllom and caulom elements (*cf.* the tendril-arm and the tendril talk of Mr. Trinkgeld.—S.P.A.). It includes one prophyll (vorblatt) of the axillary shoot and a more or less rudimentary shoot arising in its axil.

The second prophyll of the axillary shoot is abortive in most tendril-producing Cucurbitaceæ though present in a few such as Benincasa, Blastania, Müllerargia, Peponia and Momordica; the glandular scale of Luffa is also probably to be regarded as such. In Rhynchocarpa it is present in the young stage at least. In other tendril-producing Cucurbitaceæ also it is occasionally found as a second tendril opposite to the first. It has in its axil (even when abortive) floral rudiments from which either a single flower or an inflorescence is produced, usually either the one or the other. In cases where a single flower and an inflorescence are both present, the single flower is in reality one of the flowers on the inflorescence inserted very low down on its axis and hence appearing isolated. This also holds good when the single flower is ♀ and the inflorescence is ♂. The mixed inflorescence of Actinostemma with the lower flowers ♀ is to be regarded as the primitive type.

In the non-tendril bearing Cucurbitaceæ *e.g.* Ecballium, the first prophyll is also aborted. In Kedrostis spinosa and Acanthosicyos spinosa, on the other hand, both prophylls are metamorphosed to form spines. Organs besides the prophylls are also occasionally modified to form tendrilar structures in Cucurbitaceæ. The Cucurbitaceæ show further a tendency to the production of serial buds which become specially prominent where the 2nd prophyll is modified to form a tendril.

S.P.A.

Trinkgeld, Richard. Beiträge z. Morphologie d. Vegetationsorgane d. Cucurbitaceen. *Flora N.F. Bd. XVI. pp.* 270—295, 1923.

This paper, like the previous one, deals with the morphology of the tendrils of the Cucurbitaceæ. The author, however, has used experimental methods in addition to the usual ones to determine their nature. The method consisted in a very early removal of the axillary shoots and flower buds which led to the development of a lamina on the tendril-arms, thus proving the tendril-arm to be a modified leaf. Lagenaria maxima and Cyclanthera pedata were the plants used for this purpose.

By removing all terminal and axillary buds of vigorously growing young plants of Luffa sp., the author succeeded once in making a tendril develop into a shoot showing differentiation into axis, leaves and tendrils. The author thus concludes the tendril-stalk to be a shoot.

Similar experiments on Cucurbitaceae with simple (unbranched) tendrils lead the author to conclude that for such types as Momordica and Bryonia the tendrils consist of a tendril-stalk and a terminal leaf which develops into a tendril. In Cucumis on the other hand the simple tendril is made up of a modified leaf only.

The history of development of the tendrils offers an explanation of this apparent contradiction. Tendrils are produced from a leaf with an axillary shoot. From this axillary shoot, (on which the leaf is borne as the first and, in unbranched tendrils, the only arm), is developed the tendril-stalk and, if not entirely used up in the process, further tendril-arms. In Cucumis this axillary shoot is not laid down, which leads to the absence of the tendril-stalk even in the adult stage.

The author's conclusions though arrived at by other methods are in agreement with those of Neitsch and we can, therefore, regard this as a solution to this much debated problem of plant morphology.

S.P.A.

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